3. Affected Environment

This chapter provides information concerning the existing environment of the Cedar River Municipal Watershed (Watershed) that might be affected by the implementation of the action alternatives. It describes the baseline conditions against which environmental effects can be evaluated. The following resource areas are discussed:

- Geology and Soils (Section 3.1)
- Water Resources (Section 3.2)
- Forest Resources (Section 3.3)
- Fisheries Habitat and Resources (Section 3.4)
- Wildlife Habitat and Resources (Section 3.5)
- Cultural Resources (Section 3.6)
- Land Use (Section 3.7)
- Recreation (Section 3.8)
- Public Services (Section 3.9)
- Socioeconomics (Section 3.10)

Chapter 4 evaluates the effects of the proposed alternatives on these same resources and in this same sequence. Those evaluations are based on the detailed information on baseline conditions for each resource area described in this chapter.

The existing conditions of the Watershed's geology and soils are relevant in relation to how watershed operations can affect soil productivity or influence landslides or soil erosion. Sediment from mass wasting and erosion can affect water quality and fisheries habitat.

Water quantity and quality issues presented here relate to the Applicant's ability to provide a safe and reliable water supply to the region, particularly the need to maintain a firm annual yield of the water supply. Water quality conditions are also important because they affect fisheries resources. Conversely, the passage of anadromous salmonids above Landsburg has the potential to affect the quality and supply of drinking water because of decaying salmon carcasses and the scavengers they attract. The effects of the alternatives on instream flows and flooding in the lower Cedar River are also considered. Instream flows are important to fisheries resources. Flooding is an important issue because Chester Morse Lake and Landsburg Diversion have very limited capabilities for reducing flood flows.

Forest resources provide wildlife habitat and the use of those forest resources for commercial forestry provides economic revenues. The influence of the alternatives on forest age and structure and projected timber harvest volumes are important parameters to consider. Forestry operations can also influence the soil and geologic environment and therefore have the potential to affect water quality and fisheries habitat.

The primary fisheries resources of concern include the bull trout and anadromous salmonids. Their distribution and relationship to the existing environment provide the basis for understanding how various alternatives might affect them. An understanding of hatchery issues and their relationship to various salmonid species (particularly sockeye salmon) is important for evaluating the anadromous fish mitigation alternatives. Additionally, background information on anadromous salmonids and instream flows are important to evaluating the proposed instream flow measures.

The wildlife habitat and resources section describes the various species of concern and their relationship to the habitats in the Watershed. The potential effects on wildlife species will be determined according to the effects of the alternatives on watershed habitats.

Cultural resources in the Watershed include prehistoric, historic, and architectural sites. Potential effects of the alternatives on these resources should be minimized if resource locations can be identified and avoided.

Land use in the Watershed is designed to protect water supply and other natural resources. The review of the land use plans and regulations for the Watershed and adjacent areas indicates consistency with these plans.

Recreational use is not permitted in the Watershed and there is no proposal to change this. Recreational issues are important to consider, however, because boaters who use the Cedar River downstream of the Landsburg Diversion have expressed interest in how proposed instream flow commitments will affect recreational opportunities on the Cedar River.

Public services associated with the Watershed include water supply, hydroelectric generation, and flood control. The public services section presents background information on these items and highlights applicable information from the water quantity and quality section to establish the baseline for evaluating the effects of the alternatives in Chapter 4.

The socioeconomics section describes King County's population, labor force, natural resource industries (including timber harvest and recreational and commercial fisheries), and the setting of water rates. This information will be used in Chapter 4 to analyze the effects of the alternatives on employment, variations in revenue from timber harvest, and how different methods of paying for the proposed HCP action alternatives affect water rates.

Available Information—There is less than complete knowledge of many of the relationships and conditions of the resource areas described above. The ecology, inventory, and management of a large forest area is a complex and developing science. The biology of wildlife species prompts questions about population dynamics and habitat relationships.

In developing Chapters 3 and 4 of this Environmental Assessment/ Environmental Impact Statement (EA/EIS), the data and relationships used to describe the resource areas and estimate the effects of the alternatives were examined. The data and level of analysis used were commensurate with the importance of the possible impacts (40 CFR 1502.15).

When information gaps were encountered, it was concluded that the missing information often would have improved precision to estimate or better specify a relationship, but the new information would be very unlikely to reverse or nullify understood information or relationships. The basic data and central relationships are sufficiently well established in each resource area to allow decisionmakers to make well-informed choices. New information would be welcomed and would add precision, but it was not essential to provide adequate information for each alternative.

Geographic Information System—Much of the Seattle Public Utilities resource data resides in an electronic database formatted for a geographic information system (GIS). Seattle Public Utilities uses GIS software to assist in the analysis of these data. Much of the data consists of electronic map layers, each representing a particular resource or attribute (e.g., vegetation types, stream types, roads). GIS plots displaying resource data in map format and tables based on electronically measured areas and lengths are found throughout this EA/EIS.

3.1 Geology and Soils

The physiography (landforms and topography), geology, and soils of the Watershed determine how susceptible different areas of the basin are to erosion and sedimentation from different geomorphic processes. Erosion and sedimentation are of concern because of potential impacts to water quality and fisheries resources. Potential consequences of increases in erosion and sedimentation are increased turbidity and possible exceedance of the Surface Water Treatment Rule requirements for the City's unfiltered drinking water supply (see Section 3.2.5.2 for a description of the Surface Water Treatment Rule). Other consequences from increases in turbidity include sedimentation in stream bottoms which can affect both resident fish such as bull trout and anadromous fish such as salmon and steelhead trout. Additionally, soil degradation can reduce tree growth.

Erosion and sedimentation are related to the natural processes of mass wasting (i.e., landsliding) and hillslope erosion. These processes can be influenced by timber harvest practices and road construction, use, and maintenance. The following section describes the basic geology of the Watershed, along with a summary description of some of the major soils present. Chapter 4 will present the links between soils, geology, land management, and resource impacts.

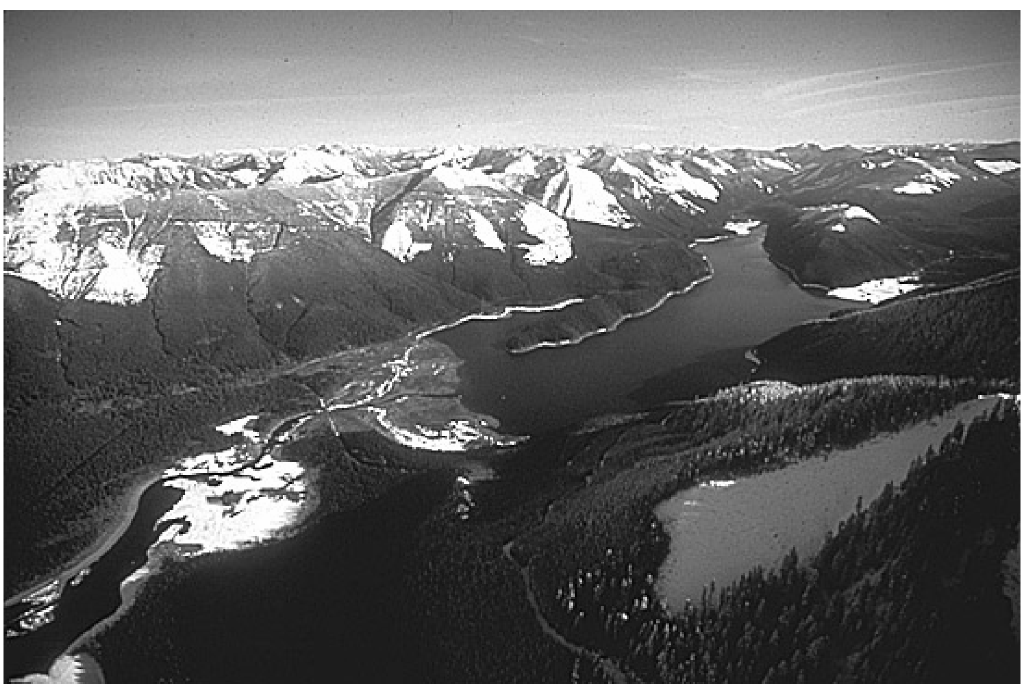
3.1.1 Physiography

The Watershed can be divided into two distinct physiographic provinces based on geology and topography: the lower municipal watershed and the upper municipal watershed (see Map 5). The two provinces are approximately defined by the mountain front of the Cascade Range. Cedar Falls lies along the boundary between the two provinces.

More detail on the Cedar River Municipal Watershed is available in the Cedar River Watershed Assessment (Foster Wheeler Environmental Corporation, 1995a, 1995b, 1995c; Technical Appendix 16). That document included modules similar to those contained in the Standard Methodology for Conducting Watershed Analysis (WDNR, 1997), a part of the Washington State Forest Practices Board Manual. The Watershed Assessment was designed to provide prescriptions for land management activities and to help prioritize restoration efforts (such as road abandonment) within the Watershed.

The lower, western portion of the Watershed consists of extensive glaciofluvial terraces with relatively gentle topography and little relief, and the rounded mountains of the Taylor Mountain/Rattlesnake Ridge area. The upper portion (about two thirds) of the Watershed contains rugged mountains, in contrast to the broad, subdued hills of the lower municipal watershed, which were overridden and smoothed out by a continental ice sheet prior to 12,000 years before present. Some streams, such as Cedar River and Taylor Creek, have

Aerial view of lower watershed



Aerial view of upper watershed

incised down through the glacial deposits, exposing older sequences of till and outwash and creating steep-walled inner gorges. The floodplains of both rivers are fairly narrow, but do contain lateral and center channel gravel bars.

The limit of the intrusion of continental ice is approximately even with the Cascade range front, at about Cedar Falls. During the most recent glacial advance, a huge glacial lake was present at the lower end of the Snoqualmie and Cedar River Valleys; this lake was called the Snoqualmie Embayment (Booth, 1988). Extensive delta and moraine deposits are present along the mountain fronts of both valleys. In the Cedar River Valley, the moraine is located adjacent to Cedar Falls, and is partially responsible for the location of the pre-impoundment Cedar Lake.

In the upper municipal watershed, upstream of Cedar Falls, the terrain is rugged with high mountains and deep valleys. The major river valleys, which include the mainstem Cedar River, the North and South forks of the Cedar River, and the Rex River, have steep sideslopes with numerous small tributaries carved into the mountain slopes. These incised tributaries are called V-notches. The valley bottoms are typical of alpine glacier valleys, with a U-shaped cross section and wide, flat valley bottom. The high portions of the mountains along the southern watershed boundary exhibit cirques, an erosional remnant of past alpine glaciers. The cirques are bowl-shaped, with a basin-like expression and steep sidewalls.

3.1.2 Geology

The geology of the Cedar River Municipal Watershed is one of the main controlling factors in the development of and ongoing hydrologic and erosional processes occurring within the Watershed. The lithology (rock types) and geologic structure directly or indirectly affect many watershed lithology processes.

Lithology

The lower municipal watershed is dominated by glacial deposits of the middle to latest Pleistocene. These deposits include glacial till and outwash. Glacial till is a compact and dense, poorly sorted deposit. Outwash is a poorly consolidated, highly permeable deposit resembling stream-deposited alluvium. The valleys of the major streams contain discontinuous remnants of relatively young fluvial terraces. These terraces are composed mainly of reworked sand, gravel, and cobbles. At Cedar Falls, a major moraine is present, deposited by the Puget Lobe of the Cordilleran Ice Sheet during the most recent glacial maximum.

Bedrock in the lower municipal watershed consists of a thick wedge of sediments deposited mostly during the Eocene. These deposits include coal beds, sandstone, siltstone, and shale. Both coal and clay have been mined within the Watershed; an abandoned mining area is located on the northwest side of the Watershed on the south slopes of Taylor Mountain.

The upper municipal watershed consists mostly of bedrock with intermittent patches of glacial till deposited by alpine glaciers (as opposed to continental glaciers). The bedrock geology consists of a series of volcanic and volcaniclastic rocks. The volcanic layers vary in composition from rhyolite and andesite to basalt. The volcaniclastic deposits include flow breccias, conglomerates, siltstones, and pyroclastic flow deposits.

Structure

The Cedar River Municipal Watershed is underlain by a series of gentle folds called anticlines and synclines. Anticlines are folds that are open in the downward direction, while synclines are folds which are open in the upward direction. The major syncline and anticlines correspond approximately with the major valleys and ridges in the Watershed. The fold axes are generally northwest-trending. These features are partially responsible for the layout of the drainage network.

3.1.3 Soils

The soils in the Cedar River Municipal Watershed have a range of characteristics that is typical of the western Cascades of Washington. The primary characteristics of soils that are pertinent to this document are related to soil effects as a result of land management activities. These include soil productivity and erodibility (erodibility is meant to include surface erosion processes only).

The Cedar River Municipal Watershed contains seven general soil associations (Soil Conservation Service, 1992). In the lower municipal watershed, the dominant general soils include the Barneston-Klaus-Skykomish, Tokul-Blethan-Ogarty, and Tokul soils. In the upper municipal watershed, soils include Nimue-Haywire-Chinkmin, Reggad-Altapeak-Index, Playco, and Kaleetan-Melakwa soils. The soils in the upper municipal watershed are typically well drained, and very deep (greater than 60 inches), but subject to erosion where the slopes are greater than 30 percent. The soils in the lower municipal watershed are also subject to erosion on slopes greater than 30 percent. Soil erodibility factor was used to determine susceptibility to hillslope erosion in the Watershed Assessment (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 16).

Soil productivity, as shown in Map 6, is generally very high in the lower municipal watershed. Site index values range from 106 to 130. In the upper municipal watershed, productivity is much lower, ranging from 59 to 109 (Soil Conservation Service, 1992). Productivity classes, a measure of the volume of timber growth on a soil, follow a similar pattern.

Soil productivity determines the rate and volume of timber growth, as well as the quantity and type of understory and ground cover plants. An indicator of site productivity for forestry purposes is the site index. There are many natural characteristics that influence site index, although a given soil series will usually have the same site index throughout its distribution. In addition, soil productivity can be affected by several timber management activities.

The effects of timber harvest activities on soil productivity (or site potential) come from a variety of sources, including compaction from equipment and yarding (Froehlich, 1973; Atzet et al., 1989); erosion from rutting or from removal of the duff (decaying organic matter) layer (Meurisse, 1988; Geppert et al., 1984); puddling or ponding from disruption of micro-drainages; and from removal of soil through landslides. In addition, the construction of new roads permanently removes soils from the base of productive soils. Prescribed burning can also affect soil productivity through loss of nutrients and by increased runoff and erosion.

Another important factor is timber harvest rotation. If rotation is greater than about 60 years, most soils will recover from compaction though natural aeration processes such as freeze-thaw and bioturbation (Miller et al., 1989).

3.1.4 Geomorphic Processes

Management practices in the Watershed can affect forest soils and geology in several ways. Primarily, the effects are related to movement of surficial materials, which include soils, weathered bedrock, and sediment. When delivered to streams, these materials can affect fish habitat (see Section 4.1.4, Fisheries Habitat and Resources). The mechanisms by which management activities affect the landscape are called geomorphic processes. Two broad groups of geomorphic processes are pertinent—erosion and mass wasting. These processes are discussed below. Evaluation of the potential effects of erosion and mass wasting includes determination of the source potential and the delivery potential.

Mass Wasting

Mass wasting has been identified as a key issue in resource management in Watersheds, most notably by the Washington State Department of Natural Resources Watershed Analysis Manual (WDNR, 1997). Mass wasting (or mass movement) is technically defined as the unit downslope movement of land area. This includes several types of movement, ranging from slow to rapid and from shallow to deep-seated. This analysis focuses on relatively rapid movements, such as debris flows and debris avalanches, which are most likely to affect public resources such as fish and water quality within the near future. Soil creep is a slow mass movement and, while important to formulating a sediment budget, it is considered to be background in nature, and not related to the proposed actions or alternatives. In this document, the more general term "landslides" is used interchangeably with shallow, rapid mass wasting.

While mass wasting occurs naturally, it can be significantly affected by land management activities, particularly logging and roading. Two major sources of landslides occur in harvested areas: clearcut units and roads (Swanson and Dyrness, 1975; Swanson et al., 1977). In the Pacific Northwest, roads (see discussion below) appear to be the cause of more landslides than clearcutting, although this varies, and seems to be highly dependent on watershed characteristics (Duncan and Ward, 1985; Sidle et al., 1985).

Timber Harvest-related Mass Wasting

Timber harvest affects landslides primarily through the loss of tree root strength after logging (Zeimer, 1981; Krogstad, 1995). Another factor is loss of evapotranspiration. This is due to lack of moisture uptake by trees on a clearcut slope; water that would have otherwise transpired to the air instead infiltrates through the soil, adding weight to the soil mass, increasing pore water pressure, and potentially leading to landslides (Anderson et al., 1976). As roots decay, their contributing strength consequently decreases (Figure 3.1-1); mass wasting has been shown to coincide with the time of maximum root strength loss, about 3 to 10 years after timber harvest (Swanston and Marion, 1991; Franklin et al., 1992; Krogstad, 1995). Root strength loss is greater in clearcuts than in partial cuts, although shelterwood cuts produce a loss in root strength similar to that from clearcuts (University of California, 1979). With time, root strength is regained, and hillslope stability returns to prelogging conditions. This process may take several decades.

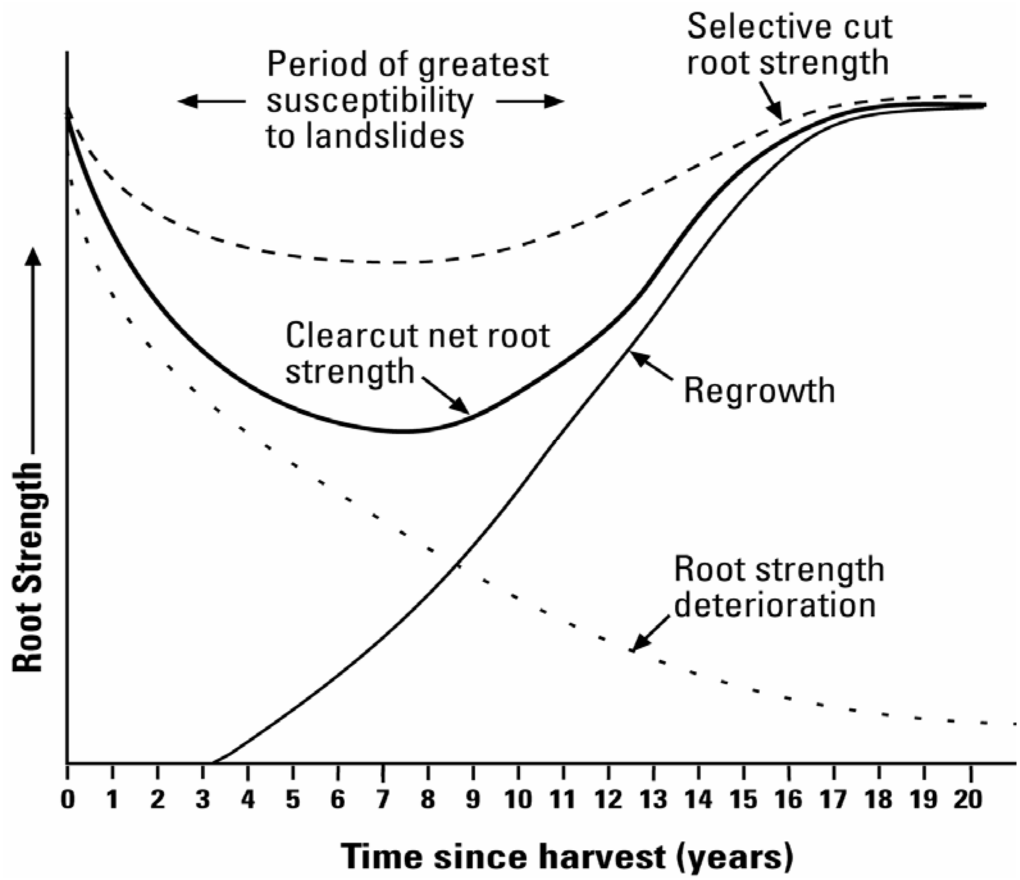
Timber harvest activities do not necessarily create an increased risk of landslides in all areas especially when designed to avoid the more sensitive areas within a watershed, such as steep slopes and inner gorges. Steeper areas are naturally more prone to landslides. Inner gorges (which include V-notches) have been shown to produce landslides more frequently than any other landform in a given watershed. In these naturally unstable areas, tree root strength may be even more important in maintaining soil cohesion. When landslides originate from the walls of inner gorges, they are quickly mobilized due to the incorporation of water from the stream, and due to the typically high gradient within the channel.

A Watershed Assessment mass wasting module, completed in 1995 (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 16), identified the mass wasting potential across the Watershed. A landslide density analysis was conducted to determine which geologic and geomorphic parameters were most associated with landslides, both timber harvest-related and road-related. Parameters associated with relatively high and low landslide density were identified. Nearly all non-road-related landslides (98 percent) occurred in clearcut areas primarily on steep slopes; it was assumed that timber harvest played a role in the initiation of most of these landslides.

Lands within the Watershed were classified as low, moderate, or high mass wasting hazard, based on the presence or absence of the key parameters. Inner gorges were assumed to have a high mass wasting potential; small-scale landslides typically found within inner gorges were accounted for in this way, since mapping at large scales was not possible.

A total of 4,350 acres was classified as high mass wasting hazard, which is less than 5 percent of the Watershed. Map 8 shows the distribution of mass wasting hazard potential throughout the Watershed. The bulk of the Watershed is designated as moderate or low mass wasting hazard. Those subbasins with a relatively high proportion of high mass wasting hazard include Otter Creek,

Figure 3.1-1. Variation of net root strength over time



McClellan Creek, Damburat, and Green Point Creek. Thirty percent or more of these subbasins were classified as high mass wasting hazard. Almost all subbasins tended to have inner gorges; these were especially well developed in the south-facing subbasins on the north side of Chester Morse Lake.

Subbasins within the lower municipal watershed tended to have very little high mass wasting potential; this is probably related to the more gentle gradients typical of this area. For example, the Williams Creek, Steele, and Walsh Ditch subbasins are classified almost entirely as low mass wasting hazard.

It is important to note that on average, the Watershed has fewer timber harvest-related landslides on a per acre basis than other parts of Washington which have been similarly analyzed (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 16). An average landslide density across the Watershed was calculated at 0.35 landslides per 160 acres, while Dragovich and others (1993a, 1993b) calculated a landslide density of 1.4 per 160 acres in southwest Washington. The difference in landslide densities between the two areas may be related to differences in geology, which are substantial. Much of the Watershed has been scoured by glacial activity, creating relatively young surfaces; in southwest Washington, many surfaces are very old and dissected.

Road-related Mass Wasting

Roads can also be a major source of landslides (Megahan, 1987; Lyons and Beschta, 1983). Road failures often originate within the fill or sidecast portion of the road prism, where overloading of steep slopes produces failure at the interface of the fill or sidecast and the native materials. Conditions leading to failure often involve improper road drainage, such as plugged or undersized culverts. In these situations, ponded water on the uphill side of the road causes an increase of pore pressure in the road fill or sidecast material. The added weight of the water, combined with the decreased strength of the fill or sidecast, causes failure. Failures also occur, although less typically, in the cut slope of roads. These occur because the lateral support for the material has been removed. These types of failures may block drainage of roadside ditches, leading to gullying of the road surface and the adjacent hillside, or fillslope failure. Road failures may also occur at stream crossings, where water and debris can scour and remove the road prism, sending debris flows down the channel below the former road crossing.

Sediment from road-related landslides is several orders of magnitude greater in volume than sediment from road surface erosion. Several studies have shown that the sediment contribution from these landslides is highly variable, ranging from 283 tons/km^2/yr to 15,565 tons/km^2/yr (Yee and Roelofs, 1980). The rate seems to increase with decreasing size of the basin studied.

In the Cedar River Municipal Watershed, there are numerous road-related landslides. Many of these landslides occur on south-facing slopes, possibly because of the more rapid snowmelt and subsequent saturation of the roadbed on these slopes. Geology was not identified as playing a significant role (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 16). Notably, road-related landslide density was found to be less than timber harvest-related landslide density (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 16).

A graph of road-related landslide density versus elevation revealed that the highest density was between 3,000 and 4,000 feet (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 16). This means that nearly all road-related landslides have occurred in the upper municipal watershed. Many of the largest of these landslides have occurred on the north side of Chester Morse Lake. The upper municipal watershed contains more of these landslides probably because of the presence of steeper side slopes and undersized stream crossings.

Additionally, many of the subbasins in the upper municipal watershed have road densities of between 3 and 6 miles per square mile. Cederholm and Reid (1987) showed that significant sedimentation of fish spawning habitat occur when road density of a watershed approaches 2 to 3 mi/mi^2. However, this may have been the result of both timber harvest and road building.

Some of the major tributaries in the lower municipal watershed have very high road densities, and thus potential for sedimentation of fish habitat. The Lower Cedar River subbasin has a road density of 6.2 mi/mi^2. While road-related landslides may not be common in the lower municipal watershed, the roads may produce sediment from surface erosion, which is discussed in the next section.

Erosion

Coarse and fine sediment can adversely affect public resources such as fish and water quality. While coarse sediment (greater than 2 mm) is generated for the most part through mass wasting, fine sediment can be supplied in significant quantities through surface erosion. There are three primary types of erosion: hillslope erosion, road erosion, and erosion from landslide scars. Erosion from landslide scars can be significant locally, but because it is relatively minor compared to the more widespread erosion from hillslopes and roads, it is not discussed further here. Such erosion can be considered continued effects of an initial landslide.

Hillslope Erosion

Hillslope erosion is caused by physical interaction between logs, logging equipment, and the soil. Background surface erosion rates in the Pacific Northwest are low, typically about 100 $tons/mi^2/yr$ (Ice, 1985). After logging, surface erosion can exceed the background rate by an order of magnitude or more. Hillslope erosion, though usually not as significant as road erosion, is nonetheless important to consider in Watershed Analysis (Rice et al., 1972; WDNR, 1993). Exposure, compaction, and disturbance may occur after timber harvest, leaving the soil vulnerable to the effects of precipitation, and in some cases, wind. Natural rates of hillslope surface erosion in forested terrain are very low. It is only when extensively disturbed by fire or logging that soils erode significantly.

One of the primary factors in hillslope erosion is the type of yarding system used. The logging systems which cause the most erosion involve ground-based equipment such as tractor and skidder logging (Rice et al., 1972). These systems can lead to soil compaction, which causes increased surface runoff, and thus increased erosion. All of these effects can reduce soil productivity. In western Washington, ground-based operations generally are restricted to slopes less than 30 percent. Rills or gullies may develop in the skidder trails or yarding paths, particularly if they are located on a steep hill and if they converge downhill.

Sediment deliverability is also a factor affecting the impact of hillslope erosion on public resources. If a hillslope has a break in slope above a stream, with the downslope side having less of a gradient than the upslope side, sediment tends to deposit before reaching the stream. Without a distinct break in slope, distance is the factor limiting deliverability. If sufficient intact vegetation exists between the site of erosion and the stream, sediment will be filtered out. Among the studies found in the literature, the typical minimum forested buffer width recommended to filter sediment is about 100 feet (Johnson and Ryba, 1992). This width generally filtered out most sediment, although the finest particles (clay-size) were found in one study to travel 300 feet through a forested buffer (Wilson, 1967).

The Watershed Assessment (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 16) estimated the hillslope erosion potential across the Cedar River Municipal Watershed (Map 9). The model for slope erodibility predicted wide ranges in erodibility across the Watershed. Most of the low erodibility areas occur in the western quarter of the Watershed where the terrain is gentle, and along wide valley bottoms in the upper portions of the Watershed, along ridgecrests, gentle ridges and saddles, and on talus slopes. Talus slopes, while steep, are highly permeable, which minimizes runoff and thus fluvial erosion.

Moderate erodibility was the most common category, with broad areas in the Taylor Mountain area, and the mainstem Taylor Creek area. Most of the toeslopes of valley sidewalls are classified as moderate erosion hazards.

Areas with a high hillslope erosion hazard are also common. The ridge north of Chester Morse Lake has large areas of high erosion hazard. This is reflected in the presence of numerous skid trails visible as much as 15 years after logging; a decrease in site productivity, while not measured directly, was indicated by the proportion of surface area still barren. Other areas include the west side of the Rex River Valley, the west side of the downstream portion of the South Fork Cedar River, and the Middle and North Forks of Taylor Creek.

The areas with very high hillslope erosion potential include portions of North Fork Taylor Creek, and small areas along the ridge north of Chester Morse Lake.

Road Surface Erosion

While not strictly classified as soils, erosion from road surfaces can be a significant component of sedimentation within a watershed. Roads have been shown to be significant contributors of fine sediments (sand and finer particles) to spawning gravels (Megahan and Kidd, 1972; Reid and Dunne, 1984). Road construction exposes bare mineral soil, and road use breaks down road surfacing into fine, detachable particles. In addition, roads may be hydrologically connected to streams where an inside ditch is constructed. Heavily used roads can contribute 1,000 times more sediment per year than abandoned roads, and 12 times as much sediment as moderately used roads (Reid and Dunne, 1984). The Watershed Assessment showed that this connectivity is common in the upper municipal watershed (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 16). Additionally, roads in the lower municipal watershed are typically not as steep as in the upper municipal watershed. In the upper municipal watershed, cut and fill slopes are both more abundant and occupy a wider portion of the road area, since the hillslopes are steeper. Roads in the lower municipal watershed are built on relatively gentle terrain, and have a lower proportion of cut and fill slopes.

For low-usage roads that are not maintained, road age is a factor in surface erosion. Roads become revegetated, sometimes with thick alder stands and/or grasses. This vegetative cover nearly eliminates surface erosion. In the Cedar River Municipal Watershed, however, some roads that are seldom used are maintained, and running surfaces are kept free of vegetation for fire safety and security reasons. This is evident in aerial photographs and through discussions with road maintenance personnel. Ditch maintenance is necessary to prevent stream diversions and subsequent road failures; the road surfaces must be clear to conduct the ditch maintenance. Although there is a tradeoff between maintaining ditches and creating road surface erosion, road maintenance prevents a greater amount of sediment delivery.

The Watershed Assessment classified the roads in the Watershed as very low, low, medium, and high erosion hazard, based on road usage, surfacing, parent material, and deliverability (Figure 3.1-2 and Map 10). From these ratings, order-of-magnitude estimates were made for sedimentation potential from road surfaces.

Subbasins with the lowest potential road-generated sediment include Findley Creek, North Fork Cedar River, and Pine Creek (see Figure 3.1-2). The subbasins with the highest road erosion potential were Taylor Creek (580 tons/mi^2/yr), the Lower Cedar River mainstem (450 tons/mi^2/yr), and Williams

Figure 3.1-2. Potential road-generated sediment, normalized, by subbasin (after Foster Wheeler Environmental, 1995d)

Creek (420 tons/mi^2/yr). These numbers are approximately 4 to 5 times the typical background rate of hillslope erosion (Ice, 1995), but considerably lower than heavy haul roads. The lowest calculated road erosion rates are in Findlay and Pine Creek subbasins, with 80 and 100 tons/mi^2/yr, respectively. However, these numbers should be considered approximate, given uncertainty in the methods used to calculate them (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 16).

3.1.5 Summary

Several important parameters can be used as indicators of potential effects of land management activities on erosion and sedimentation. For timber harvest-related landslides, the amount and location of land available for timber harvest, and the rate of timber harvest, is useful. For road-related mass wasting, the amount and type of road maintenance, construction, and decommissioning is a useful indicator. For road surface erosion, the amount of road in use and the intensity of use indicate the erosion potential, along with the amount and types of road maintenance. Specific characteristics of the Cedar River Municipal Watershed that are significant in regard to these factors include: (1) relatively low non-road-related landslide density; (2) high road density in both the upper and lower municipal watershed; (3) high sensitivity to hillslope erosion and mass wasting in the upper municipal watershed; and (4) the relatively low use rate of most roads compared to industrial forest lands.

The criteria that will be used for describing the potential impacts on this element of the environment from each alternative will include:

- Identifying areas of the Watershed prone to mass wasting and hillslope erosion and comparing their location to the Reserve area proposed for each alternative.
- Analyzing the measures proposed for each alternative for protecting areas prone to mass wasting and surface erosion that would be located outside of the Reserve area in each alternative.
- Estimating the amount of road use and construction likely to occur from each alternative.
- Evaluating the relative degree of road decommissioning and stabilization work expected from each alternative.
- Evaluating the effect of timber harvest activities on soil productivity.

3.2 Water Resources

This section describes existing water resources of the Cedar River Basin and sets baseline conditions for which environmental affects of the proposed actions and alternatives can be evaluated. Both water quantity and quality are important components of the Cedar River's ability to provide a clean and reliable drinking water supply, and to support a functional aquatic ecosystem.

The discussion of water quantity in this section begins with a description the general hydrology of the Watershed including basin description, climate and streamflows. A brief discussion of historical drainage configuration changes that have occurred at the mouth of the Cedar River and around Lake Washington is also presented. General water supply and river operations are discussed to present an understanding of the role of reservoir management in water supply, aquatic resource protection and flood protection. A brief history of the City's water claim and its relationship to instream flows follows. Next, a description of the wide variation of streamflows that exist under baseline conditions is presented, and includes discussions on high flow periods and peak flood flows, low flow periods and drought conditions. Finally, information on the City's water conservation programs is provided.

Geology and Soils (Section 3.1) reviewed the potential water quality concerns associated with mass wasting, hillslope erosion, and road erosion. In the water quality portion of this section, the potential effects are discussed more specifically in relation to water quality. The main points are as follows: (1) the existing water quality of the Cedar River is very high; (2) degradation in water quality could affect the City's ability to meet federal regulations for the treatment of surface water and potentially increase public health risks; (3) land management practices such as clearcutting near water bodies could create foraging habitat attracting deer and elk and other warm-blooded mammals which are potential sources of pathogens and viruses such as *giardia* and *cryptosporidum*; (4) the passage of anadromous fish above Landsburg has the potential to cause unwanted water quality impacts in several ways including, (a) pathogens from scavenging mammals and birds that feed on post-spawning carcasses, (b) nutrients from decaying salmon carcasses that are transmitted to Lake Youngs (the City's intermediate drinking water distribution reservoir) can result in increased algal production which in turn can create taste and odor problems and increase the risk of introducing potentially harmful disinfection by-products into the drinking water supply.

3.2.1 Water Quantity

General Hydrology of the Watershed

Basin Description

The 120,600-acre Cedar River Basin is a major subbasin within the 388,700 acre Lake Washington Watershed. The Cedar River itself begins at the crest of the Cascade Mountain Range and flows generally westward. This major river now empties into the southern end of Lake Washington at Renton. As such, surface water flows from the Cedar River have been estimated to contribute about 50 percent of the total average annual inflows into Lake Washington. The Cedar River Basin itself can be divided into three distinct subbasins: the 79,951 acre Cedar River Municipal Watershed which covers the area draining from its Cascade Mountain Range headwaters down to Landsburg, the 37,522 acre Lower Cedar River Basin which covers the area draining from Landsburg to Renton at the mouth of the Cedar River, and the 3,133 acre Walsh Ditch Subbasin. The delineation of these three subbasins, and the location of the Cedar River within the Lake Washington Watershed are shown on Map 2 (Volume 3, Resource Maps).

Map 1 (Volume 3, Resource Maps) shows the topography and the major and minor hydrological subbasins within the Cedar River Municipal Watershed. The total relief of the Cedar River Municipal Watershed is approximately 5,000 feet. The lowest portion of the Watershed occurs at the Landsburg Diversion at approximately 540 feet above mean sea level (msl), and the highest point occurs at Meadow Mountain, at 5,400 feet above msl.

Climate

The climate of the Cedar River Municipal Watershed is under the prevailing marine influence of the Pacific Ocean, generally producing mild, wet falls and winters and dry summers, and mild temperatures year round. Most of the precipitation falls as rain in the lower municipal watershed, while a mixture of rain and snow falls on the upper municipal watershed. As elevation increases, snow becomes the dominant form of precipitation. There is a strong precipitation gradient from east to west, with the western, lowermost portion of the Watershed receiving precipitation amounts up to 54 inches per year, and the eastern portion receiving an average annual 120 inches. Figure 3.2-1 is a map of the Cedar River Municipal Watershed showing average annual precipitation amounts

Figure 3.2-1. Cedar River Municipal Watershed - Average Annual Precipitation

received within the basin. There is a distinct wet season; over 75 percent of the total annual precipitation falls between October and April. Snowpack accumulations in the mountain portions of the Watershed normally peak around the beginning of April, and runoff from snowmelt usually ends by July. Peak snowpack accumulations for the Cedar River Municipal Watershed above elevation 2,500 feet average around 30 inches of snow water equivalence. The summer months are typically mild with minimal amounts of precipitation.

Morse Lake Reservoir Inflows

Morse Lake Storage Reservoir is formed behind the City's Masonry Dam and Overflow Dike facilities. As shown on Map 1 (Volume 3, Resource Maps), the Upper Cedar River and Rex Rivers are the major tributaries flowing into Morse Lake. Figure 3.2-2 shows the statistical 10th, 50th, and 90th percentile (%ile) weekly streamflow values for the Upper Cedar River tributary as measured by the U.S. Geological Survey (USGS) Stream Gage No. 12115000. The streamflow record used in the analysis is from water year 1946 to 1996, and represents natural inflows into Morse Lake. This tributary drains approximately 50 percent of the basin area behind Masonry Dam. The flow pattern is typical of rivers on the western slope of the Cascade Mountains, with low flows in late summer, high peak flows in late fall and winter from rain storms, and high sustained peak flows in late spring and early summer due to runoff from accumulated snowmelt at the higher watershed elevations. Rain falling on melting snowpack have created some of the higher individual peak flow events in the streamflow record.

Streamflows Between Masonry Dam and Landsburg Diversion

The Cedar River flows some 13.7 miles from Masonry Dam to the City's Landsburg Diversion facilities. Streamflows measured within this river reach are comprised of several flow components. Natural or unregulated local streamflows, such as from Taylor Creek, are tributary to this river reach and provide the first flow component. Streamflow statistics for Taylor Creek, one of the larger tributary streams, which has a 17.2 square mile drainage area as measured by USGS Stream Gage No. 12117000, are shown in Figure 3.2-3. The flow pattern is typical of lower elevation drainage basins in this region, with high peak flows in the late fall and winter months and low flows in the summer. Runoff in the spring from snowmelt is less of a factor than it is in the higher elevation upper Cedar River Basin.

Flow releases from the storage reservoir behind Masonry Dam make up the second flow component in this river reach. A schematic of the Cedar River water supply system is shown in Figure 3.2-4. Water can be released from behind Masonry Dam in several ways. One way is by sending water via penstocks through the City's Cedar Falls Hydroelectric Plant located approximately 2 miles downstream from Masonry Dam. Current flow

Figure 3.2-2. Cedar River near Cedar Falls, Washington - Streamflow Statistics
USGS Stream Gauge No. 12115000 (WY 1946 to 1996)

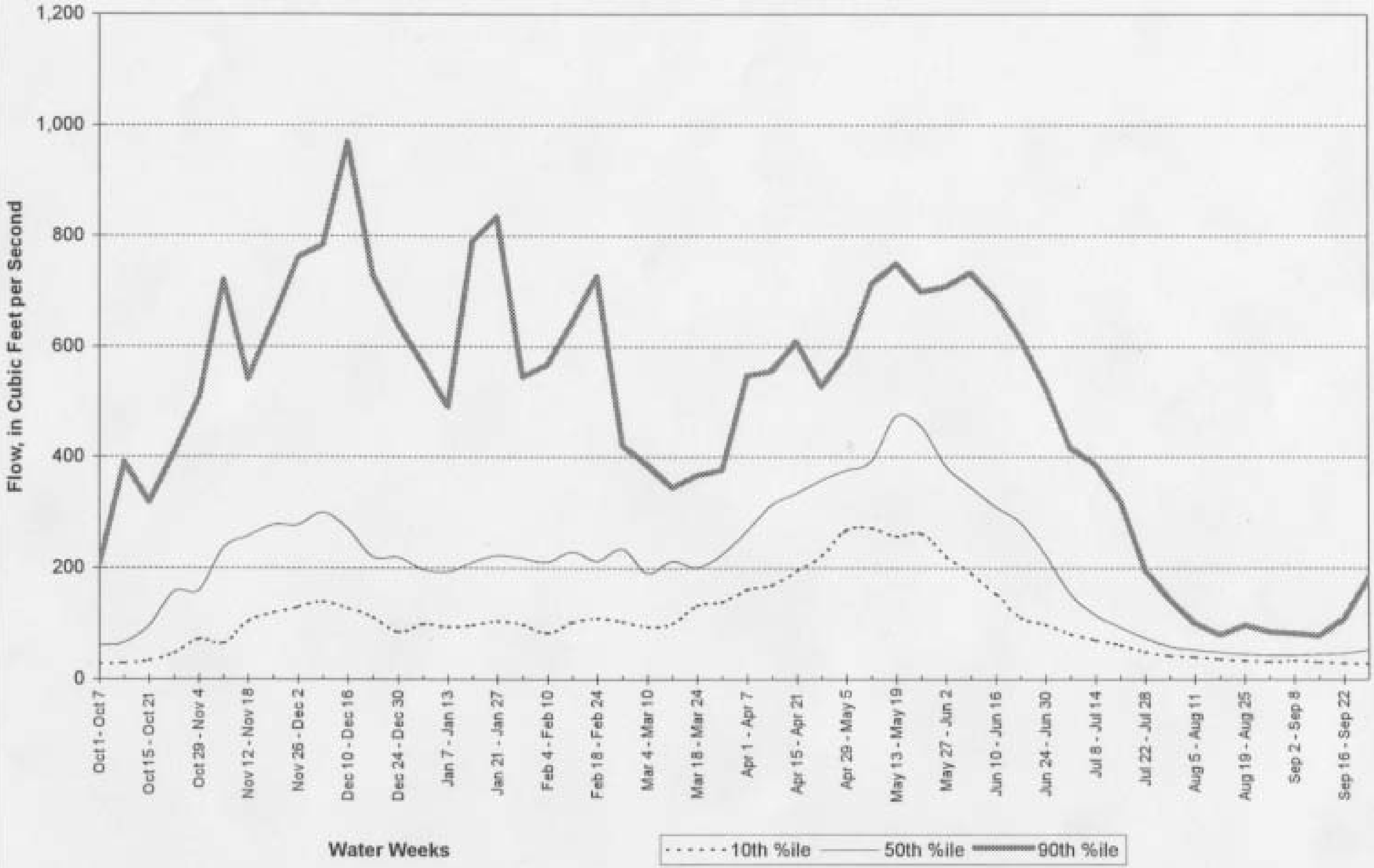


Figure 3.2-3. Taylor Creek near Selleck, Washington - Streamflow Statistics
USGS Stream Gauge No. 12117000 (WY 1957 to 1996)

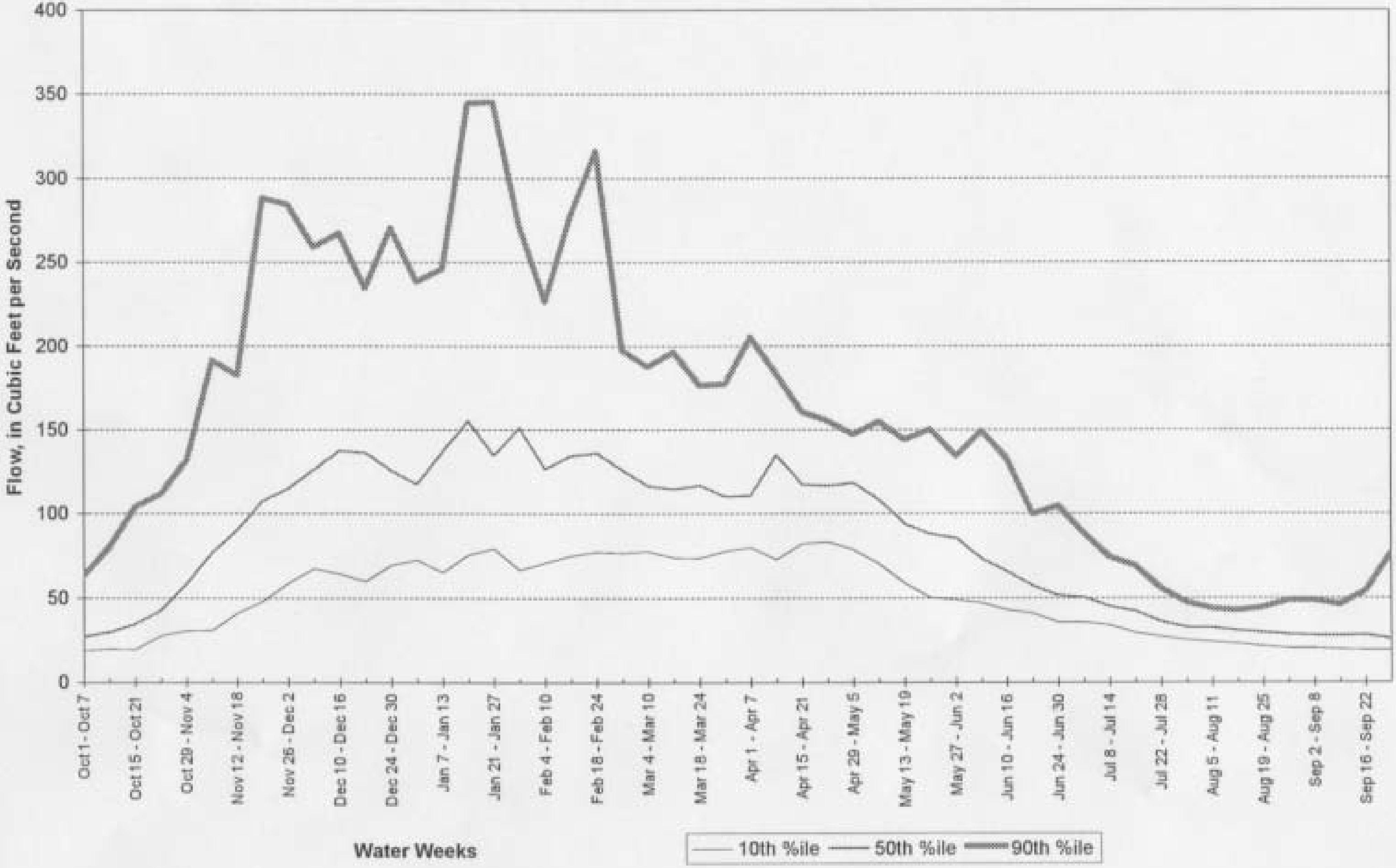
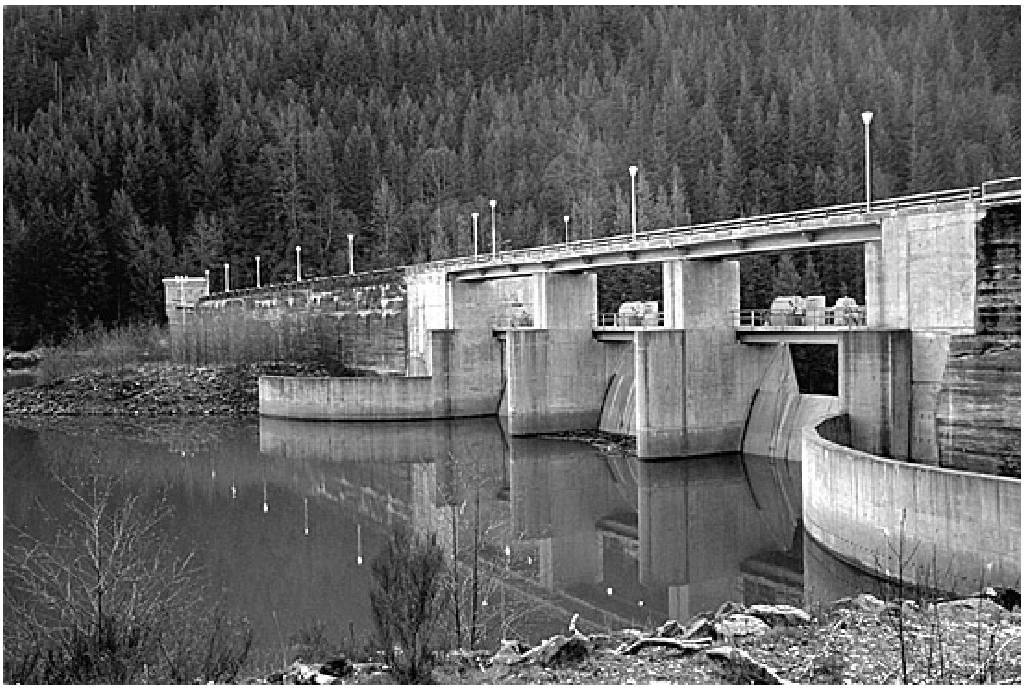


Figure 3.2-4. Schematic of Cedar River water supply system

capacities of the plant range from 0 to approximately 750 cubic feet per second (cfs). All water used for power generation is returned to the Cedar River at river mile 33.7. Another way is to release water directly at Masonry Dam at river mile 35.6 through various outlet facilities. These outlet facilities include a low level spill valve (capacity of 0 to 650 cfs), Service Spillway (capacity of 0 to 4,400 cfs), and Emergency Spillway Gate (capacity of 0 to 75,000 cfs). Reservoir flow releases are made for water supply, hydropower generation, instream flow schedules, and flood and dam safety management practices.



Masonry Dam Spillway Gates

A third streamflow component for the river reach between Masonry Dam and Landsburg Diversion is known as the Cedar Moraine Aquifer return flow, and is unique to the Cedar River system. Water seeps from the Masonry Pool Reservoir, which is the water body formed between Masonry Dam and the Overflow Dike (see Figure 3.2-4), into the moraine material that makes up the north bank of the reservoir. Some of the seepage returns to the Cedar River via Canyon Creek and spring flows, some of it flows into the Snoqualmie River via Boxley Creek, some reaches the Snoqualmie River as groundwater, and the remainder reaches the Cedar Moraine Aquifer in the vicinity of Rattlesnake Lake (see Map 1, Volume 3, Resource Maps). This feature of the Cedar River system has been studied in the past, and seepage rates have been estimated to be over 320 cfs when the reservoir is around elevation 1,560 feet. Average seepage into the moraine has been estimated to be about 210 cfs in the 1,546 to 1,550 foot elevation range, and down to about 100 cfs near elevation 1,530 feet. Most of this seepage flow returns to the Cedar River but is water that is not available for hydropower generation. Some, however, leaves the

Cedar River Basin and is not available for hydropower generation, water supply, or Cedar River instream flows.

Together, these three streamflow components produce the streamflows in the Cedar River that arrive at the Landsburg Diversion facilities.

Streamflows between Landsburg Diversion and Renton

The Cedar River streamflows which arrive at the City's Landsburg Diversion facilities at river mile 21.9 are either diverted from the Cedar River for municipal and industrial water supply purposes, or stay in the Cedar River and flow downstream in the river reach between Landsburg and the mouth of the Cedar River where it discharges into the southern portion of Lake Washington in the City of Renton, Washington (see Map 2, Volume 3, Resource Maps). Landsburg facilities include a low level diversion dam which is operated in a run-of-river mode, passing all flows over the dam which are not diverted for water supply. During periods of high turbidity in the river, or during facility maintenance, diversions may cease altogether. The City's ability to manage and control flows at the Landsburg Dam is limited. This diversion dam is too small to provide significant storage or reregulation of Cedar River flows. As such, the first component of flow in the lower 21.9 river reach can be described as Cedar River flow over Landsburg Dam.

The second component of flow is referred to as Cedar River accretion flows, which are the local tributary streamflows to this river reach. The drainage area is comprised of the Lower Cedar River Basin and Walsh Ditch Subbasin as previously described above. Accretion flow statistics are shown in Figure 3.2-5. The flow pattern is typical for lower elevation basins in this region. With increasing land development, however, the peak accretion flows from tributaries are increasing and are lasting longer (King County, 1993). The increase in the amount of impervious surfaces has led to less infiltration, increased runoff rates, and consequently lower base flows to the river in the reaches downstream from development. Additionally, private and municipal well pumping may also be decreasing accretion flows. This trend is expected to continue in the future (King County, 1993), even with mitigation proposed by King County.

These two components of flow produce the streamflows that arrive at the mouth of the Cedar River, where it now discharges into Lake Washington. Total streamflows are measured at the USGS Stream Gage No. 12119000, located at river mile 1.6 of the Cedar River in Renton. This is the same point in the river where the Washington State Department of Ecology (WDOE), in 1979, set minimum instream flow provisions (also known as the 1979 Instream Resources Protection Program (IRPP) Minimum Instream Flows) for the Cedar River. Figure 3.2-6 shows streamflow statistics for the Cedar River at Renton as measured by USGS Stream Gage No. 12119000, and includes the 1979 IRPP normal minimum instream flow regime for reference.

Figure 3.2-5. Cedar River Accretion Flows between Landsburg and Renton - Streamflow Statistics (WY 1929 to 1993)

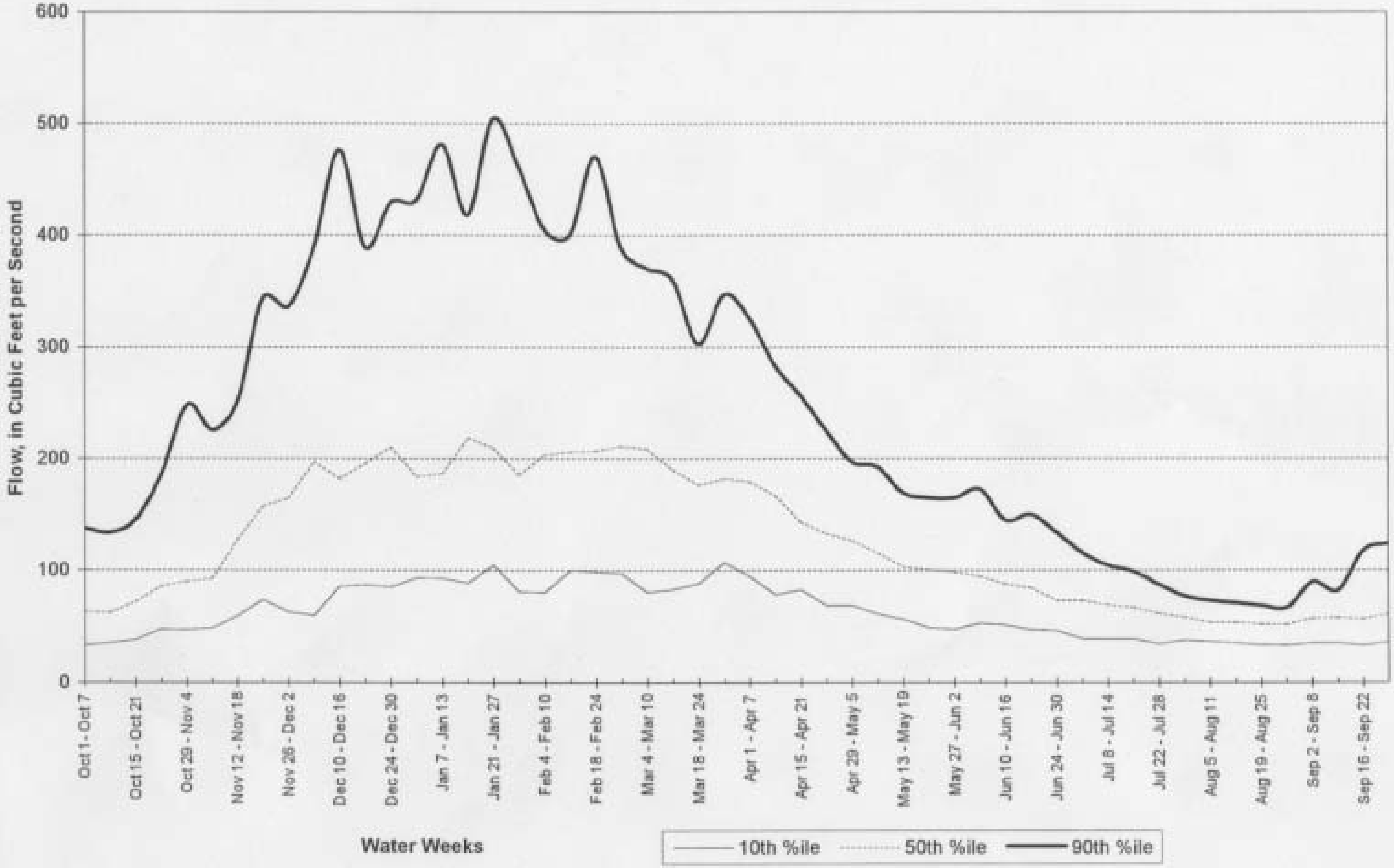


Figure 3.2-6. Cedar River at Renton, Washington - Streamflow Statistics USGS Stream Gauge No. 12119000 (WY 1946 to 1996)

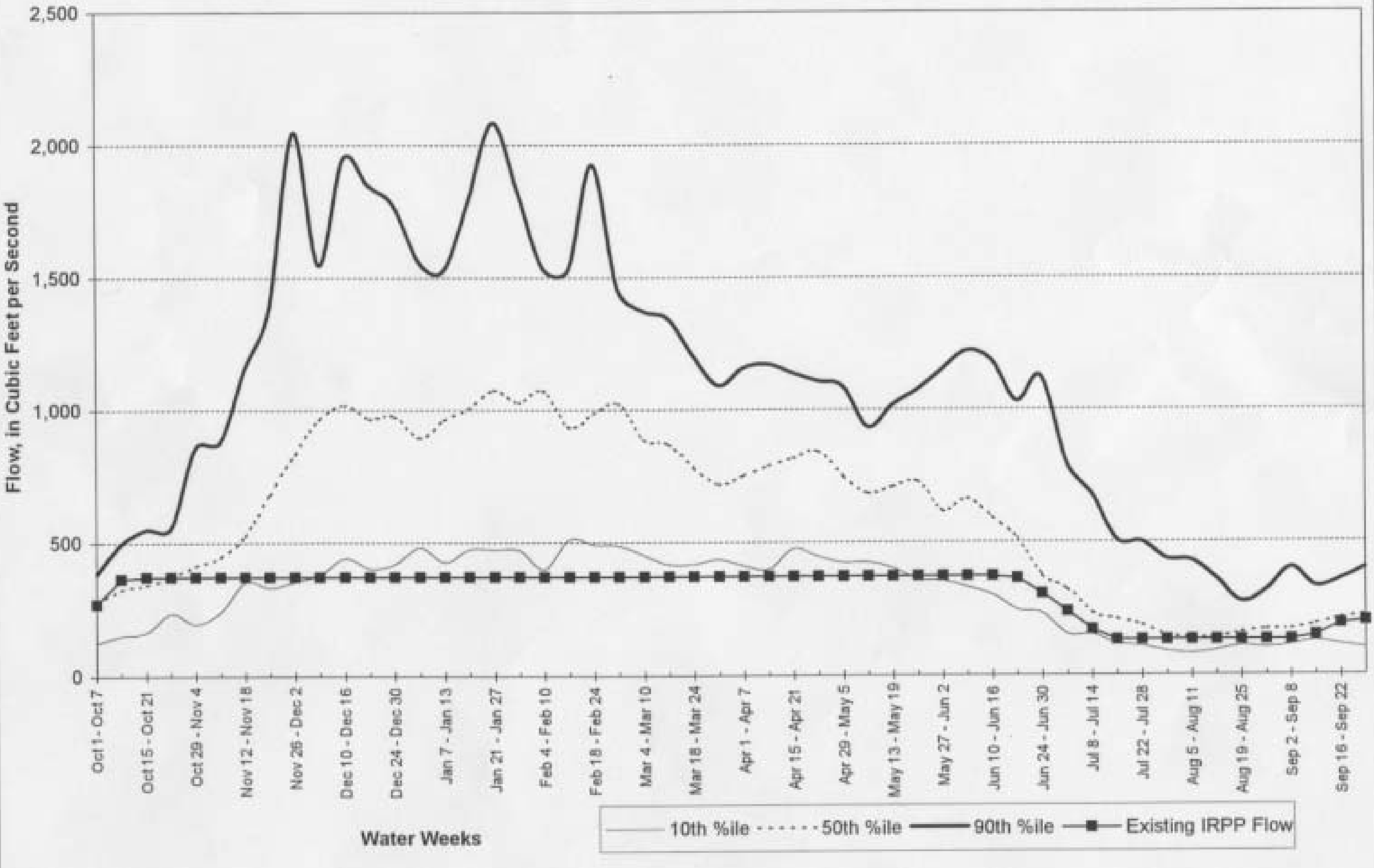
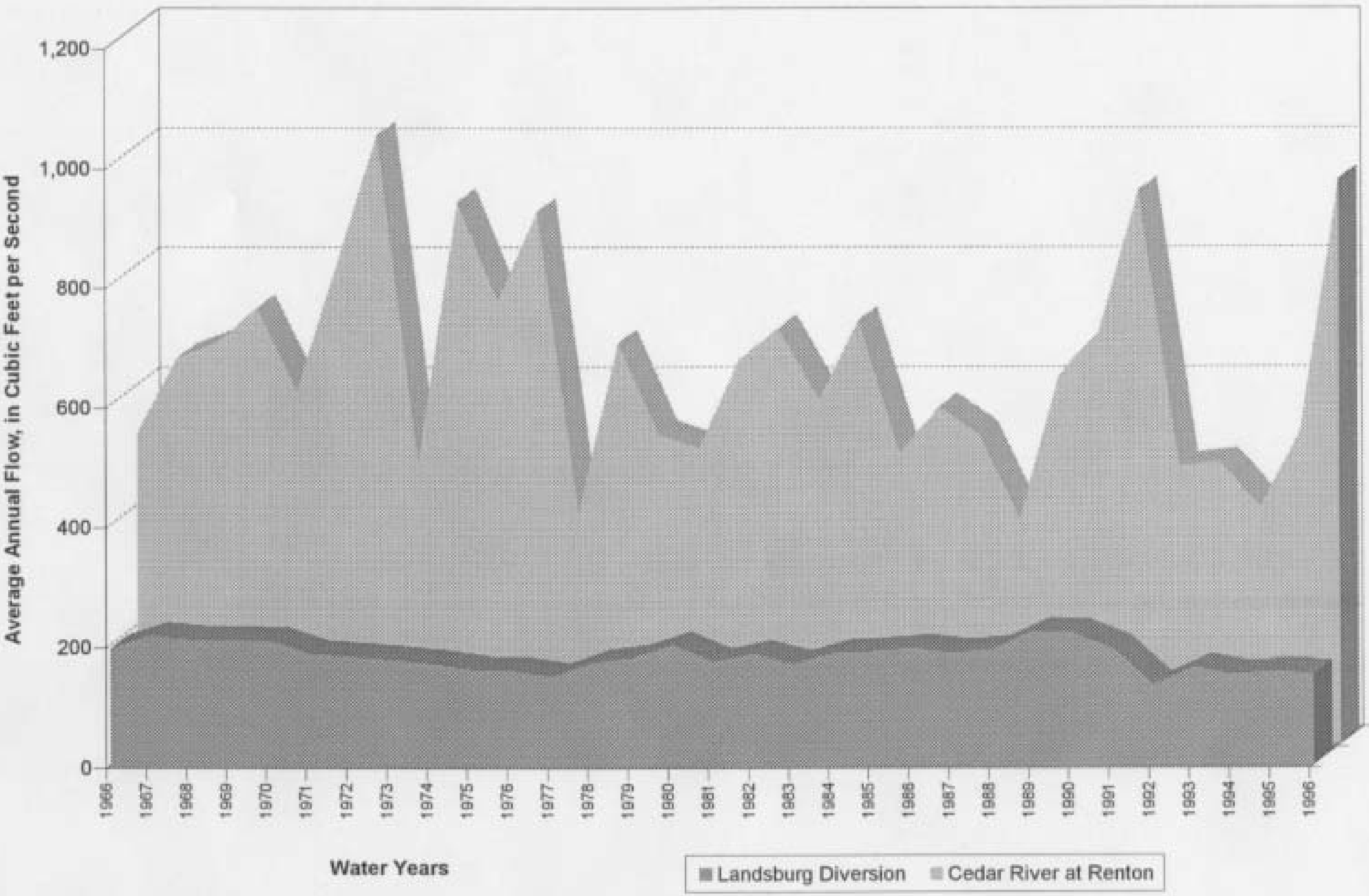


Figure 3.2-7. Cedar River at Renton and Landsburg Diversion - Average Annual Flows USGS Stream Gauge No. 12119000 and Seattle Public Utilities Data (WY 1966 to 1996)



To illustrate the annual amounts of water diverted from the Cedar River at Landsburg compared to the annual amounts of water flowing in the Cedar River at Renton as measured by the USGS Stream Gage No. 12119000, Figure 3.2-7 shows diversion and streamflow data from water years 1966 to 1996. It can be seen that diversions from the Cedar River have remained fairly constant over the last 30 years. Flow volumes in the Cedar River at Renton vary from year to year and are much higher compared to diversion volumes.

Historical Drainage Configuration Changes

For historical reference, it is important to note that the configuration of drainage in the lower reaches of the Cedar River has been modified significantly from its original state. Originally, the Cedar River flowed into the Black River and on to Elliott Bay, via the Duwamish River. In 1916, the Lake Washington Ship Canal was finished, lowering the level of the lake by about 9 feet. The Cedar River was diverted into Lake Washington by the U.S. Army Corps of Engineers to help maintain levels of the lake, continue uninterrupted operations of the locks, and to hold back the intrusion of salt water from Puget Sound. The Black River, the former outlet for Lake Washington and the Cedar River, and tributary to the Duwamish River, was blocked and filled in. A map of this historical configuration is shown in Figure 3.2-8.

General Water Supply and River Operations

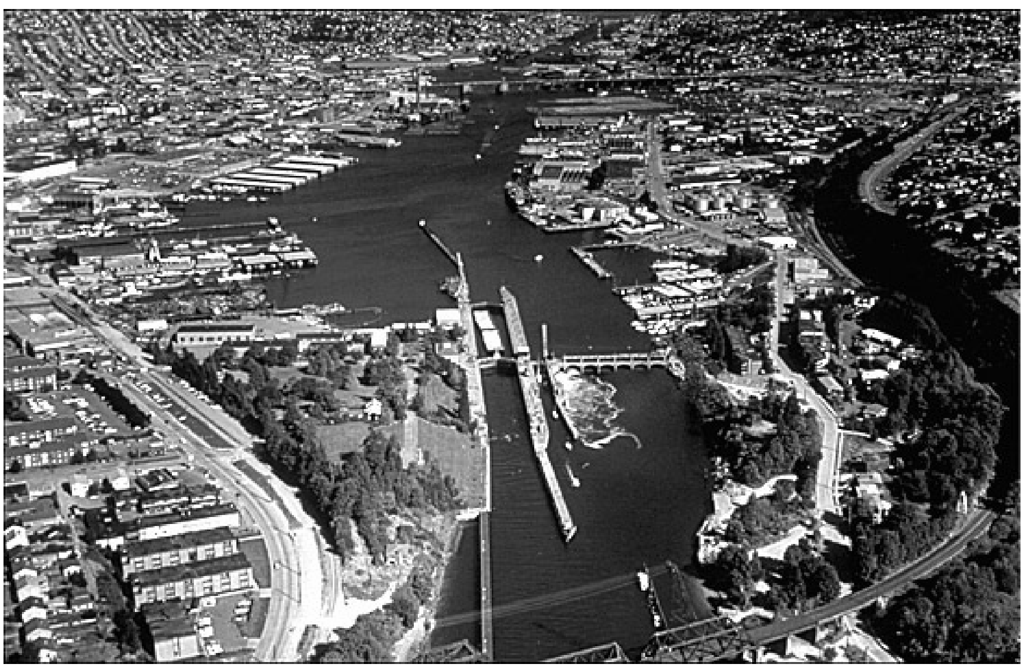
Reservoir Operations

Reservoir operating levels follow an annual cycle, which is presented in its most simplified form here. For clarity, this discussion describes Masonry Pool and Morse Lake as a single reservoir.

The water year begins on October 1st, when the reservoir behind Masonry Dam is typically near its lowest elevation. Releases from the reservoir are made to provide adequate instream flows and water supply. With the return of the fall rains, typically in November, the reservoir level rebounds, and the management of the reservoir is driven more by flood risk. Throughout the winter, reservoir levels are intentionally held up to about 17 feet below the summer refill level to maintain a volume capacity, or flood pocket, to be able to absorb storm runoff from the upper municipal watershed. The volume of the actual flood pocket varies by year and date. The flood pocket that is maintained at any given time depends on a variety of factors, including recent and expected hydrological conditions, such as storms; current snowpack; projected water supply conditions; downstream water and flow needs; and other meteorological, hydrological, and system conditions.

The spring refill period occurs between March and June, and is dependent on catching the spring snow water runoff from the mountains. Ideally, summer begins with a full reservoir. The reservoir is considered full if the elevation of the lake on or around June 1 is 1,563 feet. Because of concerns over leakage and stability of the moraine, higher lake elevations are maintained only during relatively short flood events. As the summer progresses, reduced natural inflow to the reservoir and increased water consumption cause the reservoir level to drop. By fall, sockeye salmon spawning requires increased streamflows, often necessitating significant releases from storage.

Management of the reservoir involves a continuous process of determining the amount of water to be released and the reservoir level to be attained. The decision-making process involves the recognition of the multiple objectives that the project strives to meet. The City operates these facilities primarily as a water supply source, and also as a hydroelectric power supply project. Another operating objective is to maintain target instream flow levels to benefit downstream fish populations, even when water releases from storage must be employed to serve this purpose. Fish and wildlife species resident in the reservoir are also considered, as reservoir levels and fluctuations can effect them. Flow into Lake Washington and its water control facilities at the Chittenden Locks are other key considerations. Finally, although the dams were not financed or built for flood control purposes, dam management strategies include flood control operations to benefit the lives of people and their property, as well as fisheries resources, downstream of the dams. These multiple objectives result in competing purposes for the limited amount of water storage behind the City's dams during any given season.



Hiram Chittenden Locks

Figure 3.2-8. Drainage configuration of Cedar River prior to construction of the Lake Washington ship canal and diversion of the Cedar River from the Black and Duwamish Rivers to Lake Washington

Landsburg Diversion

The City's ability to manage and control flows at the Landsburg Diversion Dam is also limited. This diversion dam is too small to provide significant storage or reregulation of flows. The Landsburg Dam is operated in a run-of-river mode, passing all flows over the dam which are not diverted for water supply. During periods of high turbidity in the river, or during facility maintenance, diversions may cease altogether. Water levels behind the dam are controlled by five tainter gates (radial self-closing gates); each gate is 20 feet wide and 6.5 feet high. The tainter gates are operated to maintain a typical pool elevation behind the diversion dam of approximately 538.5 to 540 feet. The pool created by the diversion dam submerges the diversion forebay area. The intake is at the downstream end of the forebay. The intake structure has six gated bays equipped with rotating screens. The traveling screens are contained in a screen house, which protects the screen mechanism and controllers for the sluice gates. Trash racks are mounted on the intake structure upstream of the sluice gates to protect the rotating screens from large debris. Downstream of the screen house is an open trapezoidal afterbay that directs water into the 96-inch-diameter Lake Youngs aqueduct. As shown in Figure 3.2-7, diversions from the Cedar River at the Landsburg Diversion Facility have remained fairly constant over the last 30 years, with an average annual diversion of about 180 cfs (or about 116 mgd) for the 1966 to 1996 period.

Forebay and screening facilities at the Landsburg Diversion Dam

The water supply system at Landsburg relies upon gravity to carry the water from the diversion at Landsburg to the treatment facility at Lake Youngs.

There is limited hydraulic capacity, since the elevation difference between the two points is only 50 feet, and the total length of pipeline is 9 miles. From Lake Youngs, water is treated and distributed to local storage reservoirs in the Seattle area. Because the proposed HCP involves only the Watershed and the effect of Landsburg Diversion Dam and other instream facilities, other facilities will not be discussed in this document.

The City's Water Claim and its Relationship to Instream Flows

When the City first began to divert water from the Cedar River in 1901, few regulatory systems were in place to govern water right acquisition and source development. At that time, Washington State was still 16 years away from adopting its first water code. In practice, the general western water law concept of "first in time, first in right" was accepted as the system under which priority for water rights was assigned.

In 1972, WDOE began a process to document existing water rights and to determine seniority dates among water right holders on the same stream. As part of this process, WDOE initiated flow assessments designed to protect instream flows and habitat. For situations like the City's where a use predates the state's system of assigning water rights, users were asked to submit a water claim documenting their view on the total amount and priority date of their use. The Washington State Legislature has established a legal review process for validating water claims and converting them to more conventional water rights. This legal proceeding, called adjudication, involves a complete review of all water rights and claims on a stream, and it results in judgement assigning water rights and priority dates to the various parties with interest.

The City documented its water claim on the Cedar River in 1974, indicating a priority date of 1888 and a right to divert up to 300 million gallons per day for municipal and industrial use. The WDOE acknowledges the City's claim and those of other early users. The City's water claim has not been subjected to an adjudication process.

In 1979, against the City's objection, the WDOE, through its Instream Resource Protection Program (IRPP), established by rule an instream flow regime for the Cedar River. The City's position is that its water right claim is senior by many decades, and therefore superior, to the 1979 flow regime. This position is not disputed by WDOE. Nevertheless, the City has attempted to follow the WDOE flow regime both as a water supply planning assumption and as an operating target, and the City and the other parties to the agreements underlying this HCP wish to resolve the continuing issues and establish greater long-term certainty for fish habitat and water supply planning. Since 1979, extensive collaborative studies have been conducted to help determine the fish habitat requirements and the relationship between stream flow and fish habitat quantity and quality for various life history phases of the four anadromous salmonids present in the Cedar River (Cascade Environmental Services [CES], 1991). Additional detail on instream flows in relationship to fish resources is presented in Section 3.4.2.

Wide Variation of Streamflows Exist Under Baseline Conditions

Review of past and recent streamflow measurement records made by the USGS shows that there is a wide range of variation and fluctuation of daily flow values seen in the Cedar River. To illustrate this variation in streamflows for baseline conditions, Figures 3.2-9, 3.2-10, and 3.2-11 show graphs of selected daily mean flow records taken from published annual USGS water resources data reports for water years 1974, 1981 and 1993, respectively. Over the last 30 years (1966 to 1996), these water years generally represent high (90th percentile), median (50th percentile) and low (10th percentile) flow years based on total annual streamflow. These flow measurements were made at the USGS Stream Gage No. 12119000, located in the Cedar River at Renton. The magnitudes, fluctuations and variations in streamflow values can be seen by inspection of the daily data. The 1979 IRPP flow regime is included on each of the graphs to illustrate the relative minimum instream flow values compared to what flows are actual seen in the river.

The actual flow records, or hydrographs, shown in these three example figures help illustrate typical resultant streamflow patterns in the Cedar River at Renton and are comprised of the various flow components described previously.

High Flow Periods and Peak Flood Flows

Large unregulated streamflows tributary to the Cedar River between Masonry Dam and the Landsburg Diversion Dam, as well as the tributary streamflows downstream of Landsburg, contribute to the total volume of water seen in the Cedar River. These flows make up much of the high flows and peak flood flows that are seen each and every year. Peak flood flows originating in the Cedar River headwaters are captured behind Masonry Dam and are managed through reservoir flood operations which can reduce total peak flood flows in the lower Cedar River. However, reservoir storage capacity behind Masonry Dam is small compared to the high flows associated with the upper municipal watershed. Masonry Dam was not originally built for flood control purposes and although the City's dam management strategies include incidental flood control operations to benefit the lives of people and their property, as well as fish habitat, the City's ability to control downstream flood flows has its limitations and is a complex operational activity. For more information on flood management, see Section 3.9.3, Seattle Public Utilities - Flood Control. A flood frequency table for the Cedar River near Landsburg can be found in Section 4.2.5.

Figure 3.2-9. Cedar River at Renton, Washington - Water Year 1974
USGS Stream Gauge No. 12119000 (Actual Average Daily Flows)

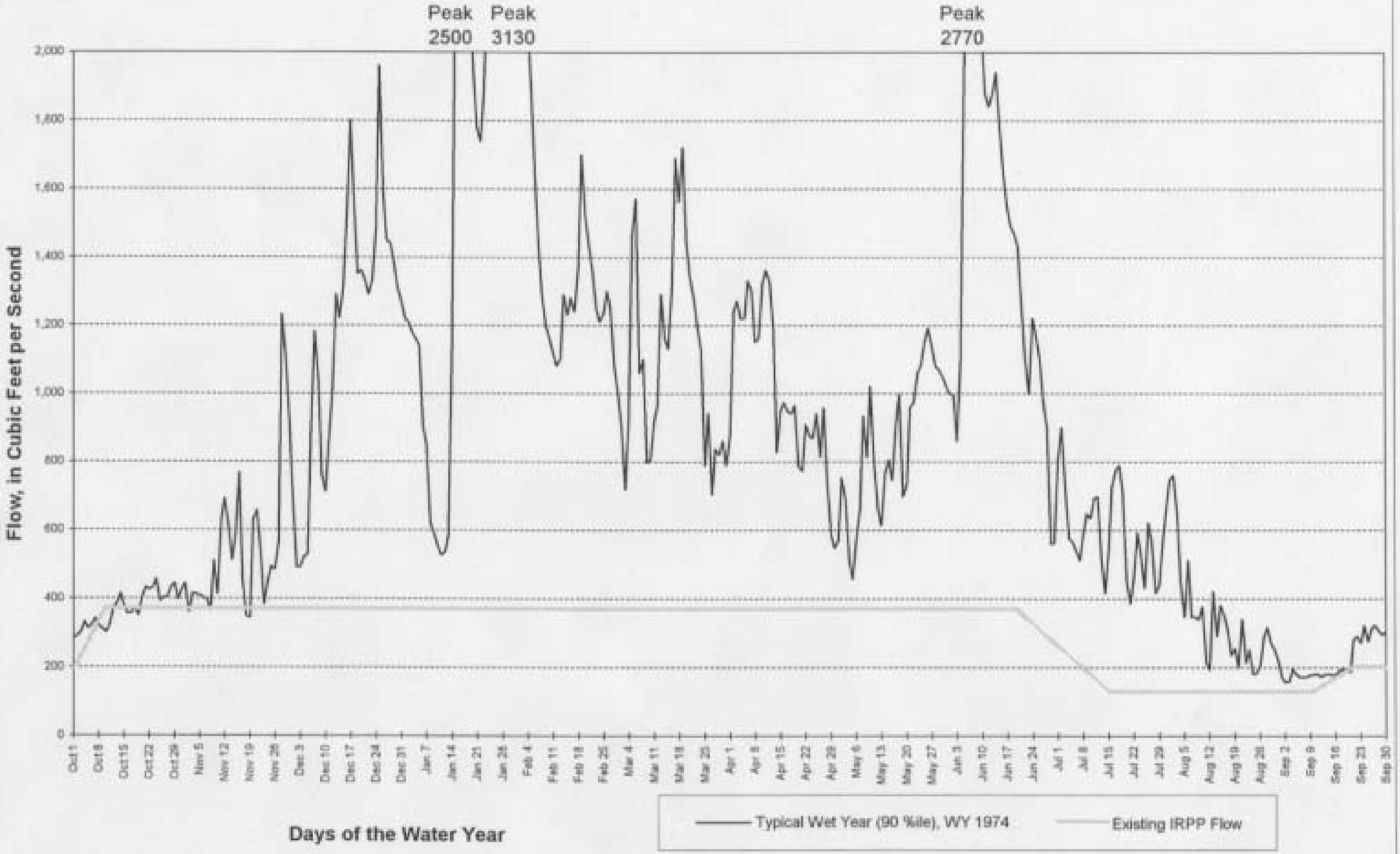


Figure 3.2-10. Cedar River at Renton, Washington - Water Year 1981
USGS Stream Gauge No. 12119000 (Actual Average Daily Flow)

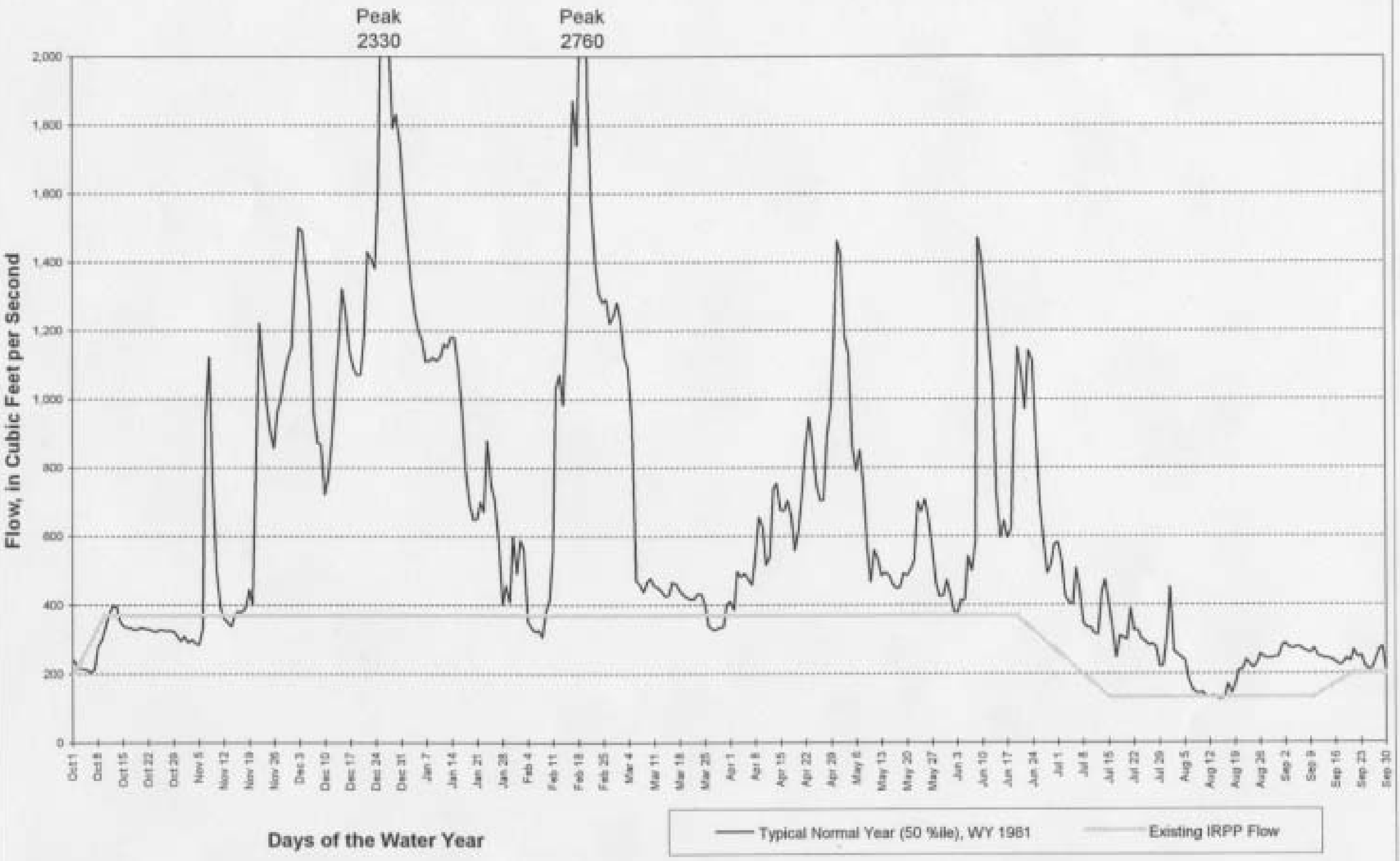


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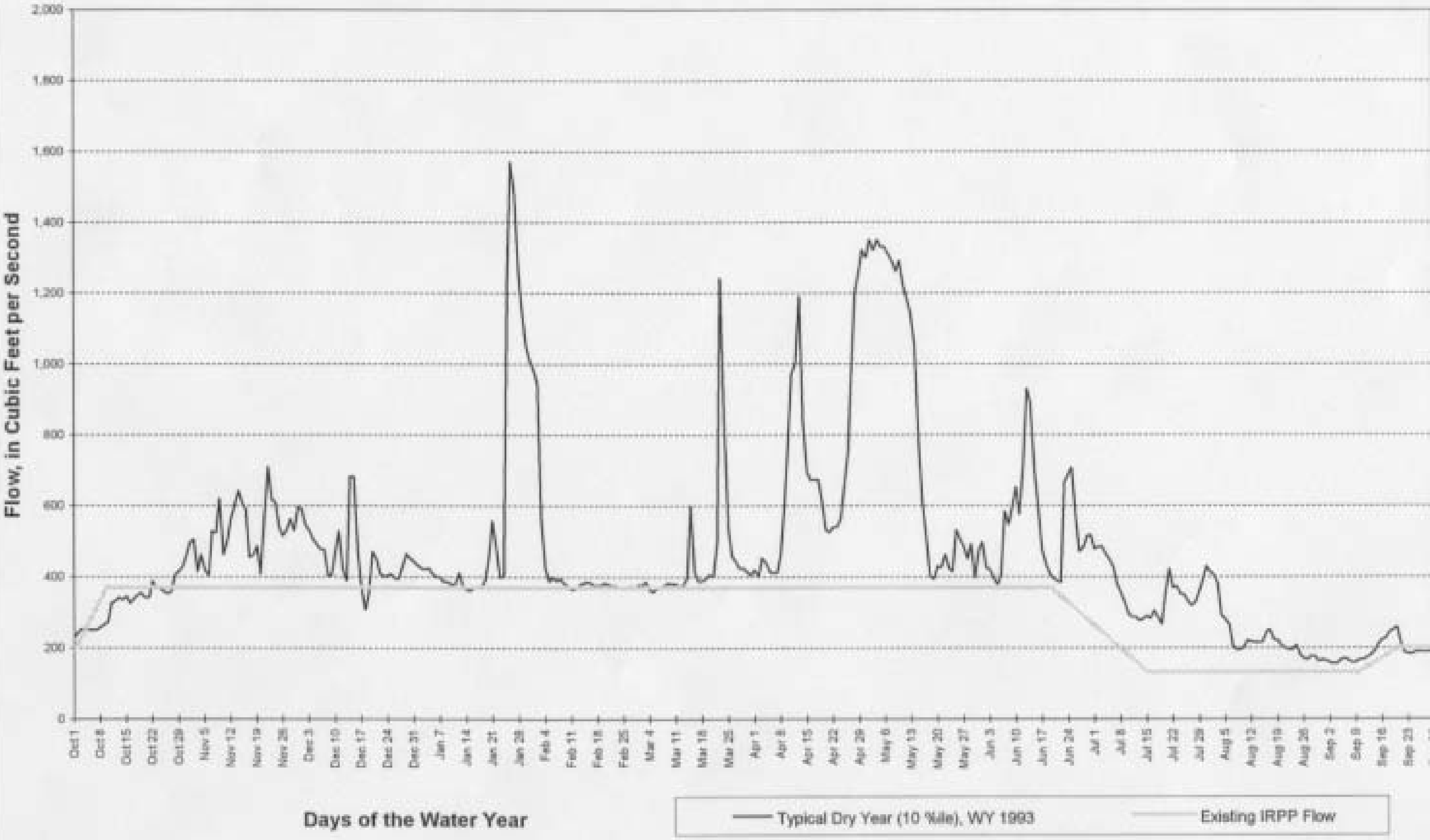
Figure 3.2-11. Cedar River at Renton, Washington - Water Year 1993
USGS Stream Gauge No. 12119000 (Actual Average Daily Flow)



Historically over time, there has been an encroachment of the floodplain by the building of homes, streets, bridges, and levees near and along the Cedar River. Flood protection provided by Masonry Dam has contributed to the development of the Lower Cedar River. Flood hazards have increased as a result of this floodplain alteration. Construction of levees in one area may protect homes, but may increase the flood hazard in areas downstream by raising flood elevations and/or increasing flow velocities. Additionally, flood storage volume is affected by development within the floodplain. As more volume is taken up by houses and businesses, less volume is available for flood water storage, and thus the flood water elevations become higher as the water seeks out additional space. As of 1993, there were about 100 homes in the 10 year floodplain, 160 within the 25 year floodplain, and 270 within the 100 year floodplain (King County Department of Natural Resources, 1996). This floodplain area includes the City of Renton, the Boeing Company, and the Renton Municipal Airport, as well as developments in unincorporated King County. As a result of development within the floodplain and levee construction, the floodplain is approximately one-third of its size 100 years ago.

Cedar River emptying into Lake Washington at Renton during January 1996 flood.

In the Cedar River Municipal Watershed, land management activities can affect water quantity primarily through timber harvest and associated road building. These activities cause a series of corresponding effects discussed below.

Timber harvest can influence stream flows by increasing the amount of snow accumulation. Loss of vegetation decreases snow interception and consequent evaporation, thereby increasing the amount of snow available for runoff (Bosch and Hewlett, 1982). The decrease in vegetation also causes a decrease in evapotranspiration (during the warmer times of the year); water that would otherwise be drawn up through the soil and evaporated through foliage remains in the soil. These effects can theoretically cause either increased summer base flows or increased peak flows (Bosch and Hewlett, 1982; Hetherington, 1987; Harr et al., 1979).

Increased base flows result from the loss of evapotranspiration by trees. Rothacher (1973) showed that at least 25 percent of a watershed must be clearcut within 5 to 15 years to show increases in base flow on the mainstem river. Logically, the smaller the watershed, the more likely this threshold will be reached.

Increased peak flows can occur in the winter, when warm, wet storms rain on the snowpack; these storms are often referred to as ROS events. Snow melts much faster during ROS events than it does from warming of the air temperature. While ROS events occur naturally, their effects can be increased by timber harvest activities.

There are two important watershed parameters that affect ROS susceptibility: elevation, and rate of timber harvest. The elevation considered to be the ROS zone in Washington is between 1,200 feet and 4,000 feet (WDNR, 1995). The rate of clearcutting of a watershed is important because mature forest stands eventually regain evapotranspiration and interception functions. Crown closure is a general indicator of these conditions, which are collectively called "hydrologic maturity." In addition, the presence of hardwoods and shrubs in a forest is a factor in hydrologic maturity; because they are deciduous, they are assumed to have roughly the same effect on snow accumulation as clearcuts. The *Washington State Watershed Analysis Manual* estimates hydrologic maturity based on crown closure and presence of hardwoods and shrubs. According to these guidelines, a forest is hydrologically mature if there is more than 70 percent crown closure and if there is less than 75 percent hardwood and/or shrub cover.

Hydrologically mature portions of the watershed within the ROS zone were estimated using the Geologic Information Systems (GIS) database. The definition of hydrologically mature used by the City of Seattle for the Cedar River Municipal Watershed is somewhat more restrictive than under the Watershed Analysis guidelines. In this document, all areas that are not hydrologically mature are considered to be hydrologically immature. The Washington DNR methodology includes a third category, "intermediate" hydrologic maturity. Only seven subbasins within the Cedar River Municipal Watershed have a portion within the ROS zone and hydrological maturity in the Basin Condition Report (Foster Wheeler Environmental Corporation, 1995a). The percentage upland in the ROS zone in these subbasins ranged from 11 to 45, while the proportion of the ROS zone that was hydrologically immature ranged from 10 to 79 percent. Hardwoods are only a minor component in the ROS zone within the Watershed.

Increases in peak flow can also occur as a result of road building. In northern California, Mahocek-King and Shelton (1987) showed peak flows from moderate-sized storms are augmented from increased runoff due to tractor logging and road building. Roads intercept groundwater in road cuts, surface flow from small drainages, and the road surface (Best et al., 1995; Megahan, 1987). Roads can gather and transmit rainfall faster than the natural landscape, altering basin hydrology (Harr et al., 1975; Harr, 1979), and extending the drainage network (Wemple, 1994; Grant, 1994). Thresholds for the contribution of roads to increased peak flows are not well established. Jones and Grant (1996) observed effects of roads on peak flows in small watersheds containing 6 percent roads. They observed effects in large basins, but the effects of roads alone could not be separated from timber harvest effects at this scale. Six percent coverage of roads in a watershed roughly equals 6.3 mi/mi^2, assuming roads are 50 feet wide. This value may be used as a rough indicator of potential for peak flow increases due to roads.

Increases in peak flows can cause scour of the streambed and erosion of streambanks, which in turn affect fish habitat and public works such as bridges. Affects of peak flows in floodplains that are of potential concern are along Rex River and the mainstem Cedar River above Chester Morse Lake because of bull trout spawning area. The floodplain along the Cedar River between Cedar Falls and Landsburg is somewhat protected from potential increases in peak flows by the operation of Masonry Dam.

Low Flow Periods and Drought Conditions

During natural low flow periods, flows are released from Masonry Dam reservoir storage to meet both water supply and Cedar River instream flow targets. Streamflows provided in the lower Cedar River from reservoir storage is a key flow component for meeting and augmenting minimum instream flow targets during times of natural low flow.

During severe drought conditions, if the level of the reservoir drops below elevation 1,532 feet, the natural topography of the preexisting lake prevents gravity flow out of the lake. During these rare periods, the City may use pumps to obtain additional water for both water supply and minimum instream flow purposes. There are two sets of pumps located on a temporary pumping barge at Youngs Bay on Morse Lake. These pumps can be positioned within the lake to allow them to draw water from elevations as low as elevation 1,502 feet, although pumping to this level is extremely unlikely to occur. Water can be pumped out of the lake and put back in just downstream of the Overflow Dike into Masonry Pool, where it then follows the regular routing. The first unit was installed during the drought in 1987; it was completely mobilized but

Floating pump barges on Chester Morse Lake

not used until the winter of 1987-1988. The second pump plant was constructed in 1992. A condition of the permit to pump below natural lake levels is that demand curtailment programs must be in place and actively reducing water consumption before the pumps can be used. Pumping operations on Morse Lake are believed to be required only once every 50 years, during extreme drought conditions (George Schneider, Seattle Public Utilities, personal communication, September 4, 1997). These conditions may occur any time of year.

The Water Shortage Contingency Plan (Seattle Water Department, 1993; Technical Appendix 10) addresses demand curtailment measures and water supply alternatives during drought conditions. This plan provides a systematic response for Seattle Public Utilities (SPU) to reduce customer demands due to a water supply emergency or drought. There are four stages of action to deal with drought conditions, depending on the severity of the drought. The first stage is an advisory stage, triggered when the reservoir storage is below standard operating capacity as of June 1, or reservoir storage and inflow are expected to be below "historical normals" for that time of the year. The voluntary stage is triggered when supply situation does not improve from the advisory stage, or when supply projections indicate that demand levels require a systematic reduction in water use. Users are asked to limit their use of water so that mandatory restrictions can be avoided. A shift to the next stage occurs when the Shortage Management Team determines that voluntary measures are not adequately reducing demand to the targeted level. Pumping of the lake may begin under this stage when storage drops below the natural lake elevation. Mandatory water restrictions are in effect concurrently with pumping.

Since the mid-1980s, SPU has initiated a wide variety of water conservation programs which encourage, through education and incentives, the efficient use of water. Collectively, these programs reduce costs in the long run by postponing (or eliminating) the need for additional water sources. In addition, during drought conditions, these efforts help maintain lake levels and may help keep more water in the river downstream from Landsburg.

Conservation programs are diverse. They include basic conservation measures such as educational pamphlets, public service announcements on radio and television, and direct mailings. Other measures include rate structuring, which increases the price of water during high demand periods. A rebate program also exists, which offers a subsidy for consumers who install water-conserving toilets, shower heads, and washing machines. Long-range efforts include changing the Washington state plumbing codes to require the use of water-efficient plumbing fixtures in commercial buildings.

Conservation efforts so far have resulted in a decrease in overall consumption; the number of SPU customers has grown 20 percent in the last 10 years, while consumption has remained the same, SPU published data from Water Supply Plan, Consumption Chapter). Between 1990 and 1996, a cumulative water savings of approximately 14 mgd has been realized due to the conservation programs. Savings are expected reach an aggregate of 21 mgd by 2005. The total water consumption by 2005 is anticipated to be equivalent to that of 1995, assuming the 1996 long-range conservation plan is adopted (Seattle Water Department [SWD], 1996; Technical Appendix 9).

3.2.2 Water Quality

The preceding section on geology and soils (Section 3.1) reviewed the potential water quality concerns associated with mass wasting, hillslope erosion, and surface erosion. In this section, these parameters, as related to water quality, are discussed further.

There are several important points to be made about water quality: (1) existing water quality of the Cedar River is very high; (2) degradation of water quality in the future could affect the City's ability to meet federal regulations for the treatment of surface water and could potentially increase public health risks; (3) clear cutting near water bodies can encourage use by deer, elk, and other creatures that are potential sources of pathogens, such as *giardia* and *cryptosporidium*; (4) interim fish hatchery operations contribute a small amount of fish waste and hatchery related chemicals to the Lower Cedar River.

Historical Water Quality

Water Quality in the Cedar River Municipal Watershed

Historically, water quality within the Cedar River Municipal Watershed has been high. City control of most of the Watershed has facilitated sustaining this level of quality. The water supply system on the Cedar River is one of only a handfull in the country that does not have to use filtration. Water quality of the lower Cedar River is affected by the source quality at Chester Morse Lake, and by quality of tributary waters entering the river between Chester Morse Lake and Landsburg.

The primary variables affecting water quality that are associated with land management activities are temperature and suspended sediment/turbidity. Fecal coliform and microorganisms are also of concern to municipal watersheds. The relationship of these parameters to land management activities both in general and specifically within the Cedar River Municipal Watershed, are discussed below.

Cedar River water

Temperature

A concern in managed forest ecosystems is summer stream temperature increases associated with timber harvesting near streams. The principal source of energy that heats small streams is incoming solar radiation that strikes the water surface and becomes stored in the water. The more canopy is removed, the greater the exposure to solar radiation which then results in stream temperature increases.

Stream width and air temperature are additional factors that influence stream temperature (Sullivan et al., 1990). Stream width is also a contributing factor to stream temperature because it affects the potential shading from streamside vegetation. Narrow streams can be easily shaded by relatively short vegetation while wider streams will remain more open, even under mature forest vegetation.

Stream temperature data are very limited for the Cedar River above Landsburg. However, limited temperature data for the Cedar above Chester Morse Lake indicate a seasonal variation similar to other streams in the central Cascades. The average temperature is at or above 12 degrees Celsius for 4 weeks in late July and early August. Even the maximum temperatures recorded are below the Washington State maximum for Type 2 (fish bearing) streams, 18 degrees Celsius. The coolest stream temperatures of the year occur between December and the end of March, when they generally remain below 4 degrees. The extreme minimum of -0.03 occurred in early February.

Suspended Sediment/Turbidity

Mass wasting from timber harvest units and roads, surface erosion, and hillslope erosion can deliver sediment to streams, which increases the suspended sediment and turbidity. Many studies have shown that turbidity varies proportionately with suspended sediment (Brown and Ritter, 1971; Barber, 1996).

Despite generally high water quality, episodes of high turbidity have occurred in the past. Turbidity exceedances (defined as greater than 5 nephelometric turbidity units [NTU]), are influenced primarily by storm activity. The primary source for the exceedance is Taylor Creek, which experiences a high level of natural wash load and receives a significant amount of road-generated sediment (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 16). Rock Creek is also a source of naturally occurring fine sediment. These turbidity events can shut down diversion of water at Landsburg when it exceeds 5 NTUs, because the water supply system is not designed to filter out such sediments.

Notably, turbidity from land management activities is mitigated somewhat by Chester Morse Lake. Fine particles, except for the very smallest, settle out in the reservoir, so that the water downstream from the Masonry Dam is very clear, except during extreme storm events. Below Cedar Falls, tributaries to the Cedar River can increase turbidity. The Watershed Assessment (Foster Wheeler Environmental Corporation, 1995b; Technical Appendix 15, 16) determined that roads within this subbasin may contribute significant amounts of fine sediment. Road surface erosion is affected predominantly by the amount of traffic on the road, so that an increase in traffic from logging operations could significantly affect turbidity via road surface erosion. Logging operations can significantly affect turbidity via road surface erosion (see Section 3.1). The Taylor River subbasin may also be naturally high in sediment, due to the materials that form the streambanks.

Construction of the fish passage facilities under the proposed alternative presents a risk of localized sedimentation. Construction in and around a stream of this size involves disturbance of the stream bed and banks, which may cause increases in suspended sediment/turbidity. As discussed in Section 2.4, future environmental reviews will be conducted as required to address project specific impacts at the time of construction. In addition, The City anticipates that the frequency and magnitude of short term turbidity events associated with construction activities will be minimized or avoided by implementation of protective measures during construction. Operations of the screening and passage facilities after construction are not expected to effect turbidity.

Fecal Coliform/Microorganisms

Episodes of high fecal coliform and total coliform levels have generally been associated with precipitation events that occur during the dry season, May through October. Water sampling indicates that there is no correlation between high coliform concentrations and *giardia* (Seattle Water Department, 1993a and b; Technical Appendices 5 and 10).

The effects of the past watershed management activities on microorganisms are not clear. A study of microbial pathogens in the Cedar River Municipal Watershed (Samadpour, 1995) looked at sources of fecal coliform. No *e. coli* of human origin were found. Animal sources of *e. coli* included coyote, elk, deer, voles, birds, cats, and mice. Of these, ungulates (deer, elk) are the most likely contributors, since they are large animals and are fairly common. However, not all of these animals carry *giardia* and *cryptosporidium*.

Nutrients

Nutrients, as used in a water quality context, primarily refer to nitrogen and phosphorous. These may be present in water in different forms, such as nitrates or phosphates. Historical data or nutrient content of the Cedar River above Landsburg are lacking. However, nutrients have probably been within the typical range for these chemicals in a forested watershed, since no significant sources of man-made nutrients are present. The City of Seattle has not used fertilizers as part of its forest management program.

Total Organic Carbon

Total Organic Carbon (TOC) refers to all dissolved carbon (in various forms) derived from natural (nonmineral) sources. As with nutrients, specific data on TOC are limited. However, a study conducted in 1996 (SWD, 1996) collected data on TOC during the 94–95 water year. An average of 0.73 milligrams per liter (mg/L) of TOC was detected, with a range of 0.42 to 1.06 mg/L.

Water Quality Downstream of Landsburg

The lower Cedar River has been rated Class AA (highest quality) to Maple Wood bridge and Class A (excellent) from this bridge to the mouth by the Department of Ecology. The lower Cedar and Lake Washington has been listed as exceeding the state water quality criteria for fecal coliform. Both bodies of water have been affected by the increasing urbanization of the surrounding areas; septic tanks and livestock have contributed to the fecal coliform levels (King County, 1993).

Safe Drinking Water Act

Public water systems are required to comply with the provisions of the Federal Safe Drinking Water Act (SDWA) and its associated regulations, as developed and implemented by the United States Environmental Protection Agency (EPA) and the Washington State Department of Health (WDOH). The SDWA was originally enacted by Congress in 1974, and was reauthorized and amended in 1986 and 1996. The most significant SDWA regulations having a direct bearing on the proposed HCP are the current Surface Water Treatment Rule (SWTR), the future Enhanced Surface Water Treatment Rule (ESWTR), and the future Disinfectants/Disinfection By-Products Rule (D/DBP).

Surface Water Treatment Rule

The SWTR was promulgated in June 1989. It focused on ensuring that adequate microbial protection via disinfection and filtration would be provided, to protect consumers of surface water sources from giardiasis and viruses. It required systems with surface water sources to install filtration treatment, unless 11 filtration avoidance criteria could be met. Meeting the 11 criteria demonstrates that the source water is of a high quality, that existing disinfection treatment is adequate to reliably and consistently kill *Giardia* and viruses, and that the quality of the water within the distribution system is maintained.

Enhanced Surface Water Treatment Rule (ESWTR)

The ESWTR will be implemented in a number of stages. The Interim Stages are expected to be promulgated by the EPA in November of 1998. It is likely that the protections against *giardia* and viruses that are included in the current SWTR, will be expanded to include *cryptosporidum*. This enhanced rule will also look at treatment plant performance measures and a number of other issues aimed at providing a higher level of protection or treatment against pathogens and viruses.

Implementation of ozone disinfection for the Cedar Supply will provide significant protection against *cryptosporidum*, and is expected to enable Seattle to meet the provisions of the ESWTR. This does assume, however, that the raw water quality is maintained at or above the current high levels. Degradation of the raw water quality would potentially reduce Seattle's ability to meet the ESWTR provisions with ozonation alone, possibly requiring the installation of particle removal technologies.

Disinfectants/Disinfection By-Products Rule (D/DBP)

Stage one of this rule is expected to be promulgated by USEPA in November of 1998. This will reduce the existing maximum contaminant level (MCL) for total trihalomethanes (TTHMs) from 100 micrograms per liter (ug/L) to 80 μg/L. It will set MCLs for other families of disinfection by-products, and it will address removal of disinfection byproduct precursors through treatment performance measurements.

The Cedar River system historically has contained relatively low levels of organics, and has had relatively low levels of disinfection by-products. If activities conducted under the Proposed HCP Alternative degrade the quality of the raw water, either microbiologically or by increasing the organic loading, it is conceivable that ozonation without particle removal would not be sufficient to meet the future standards for DBPs. Increased organic loading associated with allowing fish above the existing Landsburg Diversion Dam was a key concern discussed during fisheries facility planning. Evaluations were made based on various options for fish passage.

Lake Youngs

The regulating and storage reservoir, Lake Youngs, accepts nearly all the flow diverted from the Cedar River. It is 721 acres in area, and has a maximum depth of 100 feet. Algae production (due to excess nutrients) is currently a relatively minor problem in Lake Youngs. Algae can create taste and odor problems in the water which are not easily corrected.

In 1990, the Water Quality Division of SWD, in conjunction with Entranco Engineers, began a multi-year water quality study of Lake Youngs Reservoir. Phase I of the study (Entranco, 1993) focused on developing a computer model of nutrient levels in the reservoir, as well as evaluating some taste and odor and disinfection by-product precursor issues. Phase II of the study (Entranco 1994) further defined the water quality characteristics of Lake Youngs Reservoir, investigated taste and odor sources in Lake Youngs and downstream reservoirs, and developed an expanded model of the reservoir, which included organic parameters such as TOC. This study determined that the water quality parameters of most concern in the Lake Youngs Reservoir are phosphorus and carbon. Phosphorus has been determined to be the element that most limits the production of algae in the reservoir. Dissolved organic carbon in the water source can react with chlorine to produce THMs or with ozone to produce assimilable organic carbon (AOC).

Current soluble reactive phosphorus levels in the reservoir range from 1 to 4 μg/L in the epilimnion and 1 to 31 μg/L in the hypolimnion. Current total phosphorus levels range from 1 to 11 μg/L with an annual mean of 6 μg/L. Nitrogen concentrations measured during the spring, fall, and winter of 1994 ranged from 0.1 to 0.22 mg/L. The mean TOC concentration in Lake Youngs was approximately 1.9 mg/L from 1990 to 1993 (Entranco, 1993 and 1994).

Interim Hatchery

Currently, an interim hatchery is operated by SPU at Landsburg (see Section 3.4). This hatchery produces approximately 16 million fry annually. Water quality issues associated with hatcheries include nutrient production from fish food and fish feces and the biological oxygen demand (BOD) associated with these nutrients. BOD is related to the breakdown of organics into inorganic constituents by bacteria. During this process, bacteria use dissolved oxygen (DO) and may cause low levels of DO that can harm other aquatic organisms. Hatchery operations are regulated by the State to control nutrient output.

3.2.3 Summary

Water Quantity

The Cedar River experiences a wide variation of streamflows under baseline conditions. Some of these variations are influenced by the City's management of the reservoir behind Masonry Dam, although this influence is at times limited, as in the case of reducing peak flood flows in the lower Cedar. This is because reservoir storage behind Masonry Dam is relatively small, and large unregulated streamflows tributary to the Cedar River between Masonry Dam and the Landsburg Diversion Dam, as well as the tributary streamflows downstream of Landsburg, contribute much of the total volume of water seen in the Cedar River. Landsburg Diversion Dam is a run-of-river facility and is too small to provide significant storage or reregulation of flows.

During natural low flow periods, flows are released from the Masonry Dam storage reservoir to meet both water supply and Cedar River instream flow needs. Streamflow provided in the lower Cedar River from reservoir storage is a key flow component for meeting and augmenting minimum instream flow targets during times of natural low flow.

The Cedar River has undergone changes that have affected the hydrology of the system. These alterations include but are not limited to construction and operation of the Masonry Dam, routing of the mainstem of the Cedar River to drain into Lake Washington, and major alteration of the floodplain from encroaching urban development and diking. In the Cedar River Municipal Watershed, timber harvest rate and road density are the main variables to be examined for potential effects on peak flows. Portions of the Watershed are currently vulnerable to ROS events, which may lead to localized scouring and stream bank erosion.

Downstream of Landsburg, WDOE IRPP instream flow recommendations are used as guidelines for aquatic habitat protection. However these instream flow recommendations are nonbinding on the City's water right.

Water withdrawals for Municipal and Industrial uses from the Cedar River have remained fairly constant over the last 30 years. The City has initiated a wide variety of water conservation programs which encourage, through education and incentives, the efficient use of water.

Water Quality

The Cedar River above Landsburg is a high quality water source. However, it is vulnerable to several inputs. Due to regulatory and operational constraints, the Watershed is highly susceptible to changes in land management and fish passage above Landsburg. Suspended sediment and turbidity, fecal coliform, nutrients, pathogens, and disinfection by-products are of most concern. These parameters will be the primary factors used in evaluating potential effects of the various alternatives.

3.3 Forest Resources

3.3.1 Introduction

This section addresses the forest resources in the Watershed. Section 3.3.2 describes the existing successional stages, forest stand ages, and vegetation types. Section 3.3.3 describes the history of commercial timber management in the Watershed. Section 3.3.4 describes current timber management under City of Seattle Secondary Use Ordinance. Section 3.3.5 describes the silvicultural practices and timber harvest methods commonly used for commercial timber operations.

Currently, much of the Watershed forested habitat is relatively young because of timber harvests that have occurred over the last 100 years. Approximately 16 percent of the forest lands are defined as old growth forest. Whereas in the past there were multiple owners and managers of forest lands within the Watershed, the Applicant currently owns all of the forest lands within the Watershed above Landsburg.

The current distribution of forest seral (successional) stages and forest stand ages will be used in Section 4.3 to evaluate the environmental consequences of the alternatives. Specifically, the amount and seral stage of forests placed in Reserves, the amount and seral stages of forests available for timber harvest, how timber harvest affects the structure of the forest, and the volume of timber available for harvest will be discussed. This information is also important for evaluation of the effects of the alternatives on soils (Section 4.1), water quality (Section 4.2), fisheries (Section 4.4), wildlife (Section 4.5), and socioeconomics (Section 4.11).

3.3.2 Successional Stages, Forest Stand Ages, and Vegetation Types

Data on existing conditions of forest resources in the Watershed are based on information from past owners in the Watershed, satellite and GIS vegetation mapping, and forest and vegetation inventories conducted in 1974 and from 1992 through 1994. The initial 1992 forest inventory represented a 28 percent sample of the Watershed, and the next 2 years of sampling provided additional information on overstory and understory conditions (City of Seattle, 1998). Data are provided below address to forest successional stages and forest types.

Successional Stages

Plants influenced by disturbances from natural events, animals, and people respond by growing in patterns of succession. Disturbance refers to events that alter the structure, composition, and function of terrestrial or aquatic habitats. Historically, disturbances in the Watershed generally followed cycles of infrequent, high-intensity events (such as drought, floods, wind, or crown fires) interspersed with frequent, low-intensity events (such as nonlethal underburns, annual wildlife grazing cycles, or scattered tree mortality). Much of the original forest in the Cedar River Municipal Watershed regenerated after large natural fires in the 1300s, 1400s, and 1700s (USFS, 1996). Windstorms, which constituted an important source of low- to mid-level disturbance, left lower strata intact, but felled larger trees (Franklin, 1988).

Succession refers to the generally predictable process of changes in structure and composition of plant and related animal communities over time. Successional (or seral) stages are often described in terms of early seral-grass forb stage, early seral-open canopy stage, mid-seral-closed canopy, mature forest, late successional forest, and old growth forest. Seral stages are defined based on the condition of the vegetation and animal communities that occur in each. Early seral stage forests, including grass forb and open canopy stages, are dominated by plant species that grow well in direct sunlight and are dominated by grasses, forbs, shrubs, and very young trees up to about 10 to 15 feet tall. As trees get taller, their crowns begin to shade the forest floor, and shrubs and tree seedlings that need direct sunlight begin to die out. Mid-seral-closed canopy forests are characterized by closed canopies. The lower branches of the trees also die because of lack of sunlight. In the later decades of this stage, trees that can survive in shaded conditions have established themselves and the canopy has begun to open. Because the common commercial rotation age in western Washington is 60 to 80 years old, it is the mid-seral-closed canopy forests that are most commonly harvested in commercial timber operations. In mature forests, the trees are larger in diameter, the closed canopy has opened more, and there are considerably more understory trees and shrubs. In late successional forests, the trees are older and larger, the canopy is more open, some larger trees have died and become snags, and there is a well developed understory of large trees.

As used here, an old growth forest is a stand with moderate to low canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; a high incidence of large trees, some with broken tops, and other indications of old and decaying wood (i.e., decadence); numerous large snags; and heavy accumulations of wood, including large logs, on the ground. Sunlight gaps are present as a result of fallen trees, and smaller trees exist in various age classes in the understory, with low shrubs and herbaceous vegetation on the forest floor. The structure of old growth stands can vary depending upon vegetation, elevation, and microclimates. For example, high elevation late successional and old growth forest in the true fir/mountain hemlock zone can be very different than old growth forests at lower elevations. The importance of late successional forest and old growth forest habitats for wildlife is discussed in Section 3.5.

Nearly 86 percent (12,030 out of 13,889 acres) of the existing old growth stands in the Watershed were transferred to the City of Seattle by the USFS, under an act of Congress called the 1992 Cedar River Watershed Exchange Act. The act directed an exchange that gave the City ownership of all remaining federal land in the Cedar River Municipal Watershed. The transfer of ownership includes a deed restriction that the City of Seattle continue to manage former USFS land within Critical Habitat Unit #WA-33 as late successional habitat. Deed restrictions also prohibit the harvest of all old growth received as part of the land exchange.

Forest Stand Ages and Seral Characteristics

The current status of the forest stand ages and seral stages in the Watershed is summarized in Table 3.3-1. As discussed later in the History of Timber Harvest in the Watershed section, much of the earlier timber harvest occurred after 1910. Therefore, the current seral stage conditions in the Watershed show a predominance of early to mid-seral aged stands under 80 years and lesser amounts of older residual late successional and unharvested old growth stands. Approximately 19.0 percent of the forested portion of the Watershed is in the Early seral-open canopy stage development, including both the grass forb and open canopy stages; 64.0 percent is in mid-seral-closed canopy stage, 1.0 percent is in mature forest, and 16.2 percent is in old growth forest. Map 4 (Cedar River Municipal Watershed current stand age) shows the current Watershed forest distribution in the following age classes: 10-year age classes below age 120 (early seral-grass forb, early seral-open canopy, mid-seral-closed canopy, mature forest), 121 to 189 years (late successional), and greater than 189 years (old growth).

There are 13,889 acres of old growth forest in the Watershed (see Table 3.3-2). Approximately 734 acres of old growth forest are in scattered parcels in the western lowlands and the central portion of the Watershed downstream of Landsburg, and 13,155 acres are in more contiguous blocks (2,000-plus acres per block) in the higher elevations of the eastern half of the Watershed. About 18.5 percent of the old growth is at lower elevations, and the other 81.5 percent is at elevations above 3,000 feet.

Table 3.3-1. Current forest stand age and seral stage distribution for the Cedar River Municipal Watershed (in acres)*

Stand age (years)		Acres	Acres
0-9	Early Seral-Grass Forb Stage	1,937	
10-19	Early Seral-Open Canopy	6,035	
20-29	Early Seral-Open Canopy	7,638	
		Early Seral Subtotal	15,610
30-39	Mid-Seral-Closed Canopy	7,605	
40-49	Mid-Seral-Closed Canopy	10,767	
50-59	Mid-Seral-Closed Canopy	6,470	
60-69	Mid-Seral-Closed Canopy	17,879	
70-79	Mid-Seral-Closed Canopy	11,871	
		Mid Seral Closed Canopy Subtotal	54,592
80-89	Mature Forest	950	
90-99	Mature Forest	112	
100-119	Mature Forest	12	
		Mature Forest Subtotal	1,063
120-189	Late Successional Forest	91	
		Late Successional Forest Subtotal	91
≥ 190	Unharvested Old Growth	13,889	
		Old Growth	13,889
Acres of forest of unknown stand age			222
Total			**85,477**

*See Map 4 - Existing Forest Stand Age

Table 3.3-2. Old growth forest in the Cedar River Municipal Watershed by elevation

Watershed area	Acres of old growth less than 3,000 feet in elevation	Acres of old growth greater than 3,000 feet in elevation	Totals
lower municipal watershed*	416	318	734
upper municipal watershed	2,149	11,006	13,155
Totals	2,565	11,324	13,889

* lower municipal watershed refers to forest lands managed by the City of Seattle between the Masonry Dam and the Landsburg Diversion Dam (see Map 4 - Existing Forest Stand Age.)

Vegetation Types and Dominant Tree Distribution

The distribution of dominant tree species ranges from Douglas-fir, western hemlock, and red alder at the lower elevations (500 to 3,000 feet above sea level), to western hemlock at middle elevations, and to true firs (Pacific silver fir, noble fir, and Subalpine fir) and mountain hemlock at upper elevations from 3,000 to 4,800 feet. Approximately 84 percent of the total forested area within the Watershed is second growth forest. Approximately 44 percent of the second growth is dominated by Douglas-fir, 2 percent by red alder, 6 percent by western hemlock, 34 percent by true fir, and 14 percent conifer mix. Old growth forest constitutes approximately 16 percent of the forested area within the Watershed. Approximately 10 percent of this old growth is dominated by Douglas-fir, 2 percent by western hemlock, 65 percent by true fir, 5 percent mountain hemlock, and approximately 18 percent conifer mix.

Site Productivity

The Watershed includes some of the most productive forest lands west of the Central Washington Cascade Mountain Range (Lillybridge et al.). These highly productive soils are in the western hemlock zone, particularly well-drained soils over 20 inches deep (see Map 6). It also includes some low site productivity lands on shallow soils or steep well-drained soils. The productivity in the Watershed varies greatly, mostly as a function of soil temperature and nutrient availability. At the highest elevations, growth potential is also influenced by snowpack depth and duration, which directly affects soil temperature. Reference Section 3.1.3, Soils, for further discussion on soil productivity and effects of timber harvest activities on soil productivity.

Endangered and Threatened Plant Species

Several references were consulted to determine if any plant species that are likely to occur in the Watershed are listed as endangered or threatened species under the Endangered Species Act (ESA). These include the Washington Natural Heritage Program species list (WNHP, 1997), FWS (1994), the Federal Register (1994), Hitchcock and Cronquist (1973), Hitchcock et al (1969), and Potash (1991). The WNHP was contacted in March 1998 for specific information on the occurrence of endangered, threatened, and sensitive species in King County.

Federal Species

Two plant species within Washington are listed as endangered by the FWS: swamp sandwort (*Arenaria paludicola*) and Bradshaw's desert parsley (*Lomatium bradshawii*). Swamp sandwort, listed as occurring historically in King County, has been found in swamps, mostly along the coast. It ranges from prairies near Tacoma and coastal southwestern Washington to Los Angles County, California. Suitable habitat is not likely to occur in the Watershed because habitat for this species occurs at higher elevations than exist in the Watershed. Bradshaw's desert parsley is also unlikely to occur in the Watershed due to a lack of suitable habitat (Hitchcock et al., 1969).

Only one plant species, golden Indian-paintbrush (*Castilleja levisecta*), is listed as threatened by the FWS that has historically occurred, or is likely to occur, in King County. It occasionally occurs in lowland areas in Puget Sound. It is unlikely to occur in the Watershed because the Watershed is at a higher elevation than preferred by this species (Hitchcock, 1969). Swamp sandwort is listed as Endangered and has historically occurred or is likely to occur in King County.

State Species

Swamp sandwort (*Arenaria paludicola*), a state endangered species, is listed as possibly extinct in King County. As described above, swamp sandwort grows along the western portion of Puget Sound and along the coast. Suitable habitat is unlikely to occur within the Watershed. Golden Indian-paintbrush (*Castilleja levisecta*) is also listed as a state endangered species expected to occur in King County. As described above, it grows in prairies and coastal areas and is not likely to occur within the Watershed. Suitable habitat for the following threatened species is likely to occur in the Watershed. Water lobelia (*Lobelia dortmanna*) is expected to grow in shallow water at the margins of lakes and ponds. Adder's tongue (*Ophioglossum pusillum*) is likely to be found in wetlands at the lower elevations of the Watershed. Choriso bog-orchid (*Platanthera chorisiana*) has been found on the Mt. Baker-Snoqualmie National Forest in very wet meadows, rocky seeps, and lake shores at elevations from 1,000 to 6,000 feet. Tall bugbane (*Cimicifuga elata*) may be found in moist forests at low elevations.

Eighteen state-sensitive plant species could be found in the Watershed. They are listed along with the state-listed threatened and endangered species in Table 3.3-3, Endangered, threatened, and sensitive vascular plants of King County, Washington.

Noxious Weeds

Noxious plant species are nonnative plants that can aggressively invade an area. They can decrease forest productivity and alter ecosystems by out-competing native early successional species, reducing native biodiversity. Road construction machinery and logging trucks often carry dirt and mud containing weed seeds on their tires and carriages. Open road beds and side slopes and newly harvested areas often provide a good seedbed and adequate light for these pioneer species to grow and reproduce, (Potash, 1991).

The Washington Administrative Code and the Revised Code of Washington (Titles 16 and 17, 1992) list noxious weeds and control measures that the State requires. Information on controlling noxious weed is available (Potash, 1991; Smith-Kuebel and Lillybridge, 1993; and W. H. White, 1995). Land owners have a legal obligation to control noxious weeds. A land owner may be subject to fines for failing to control noxious weeds, or the county may elect to control the weeds and charge the land owner. In addition to legal requirements, noxious weed infestations can impair timber production by inhibiting the establishment of tree seedlings and/or slowing the growth of seedlings and young trees.

Table 3.3-3. Endangered, threatened, and sensitive vascular plants of King County, Washington

Scientific Name	Common Name	State Status
Arenaria paludicola	Swamp sandwort	Possible extirpate
Aster curtus	White-top aster	Sensitive
Botrychium lanceolatum	Lance-leaved grape-fern	Sensitive
Botrychium lunaria	Moonwort	Sensitive
Botrychium minganense	Victorin's grape-fern	Review
Botrychium pedunculosum	Stalked moonwort	Sensitive
Botrychium pinnatum	St. John's moonwort	Sensitive
Campanula lasiocarpa	Alaska harebell	Sensitive
Carex buxbaumii	Buxaum's sedge	Sensitive
Carex comosa	Bristly sedge	Sensitive
Carex pauciflora	Few-flowered sedge	Sensitive
Carex saxatilis var. major	Russet sedge	Sensitive
Carex stylosa	Long-styled sedge	Sensitive
Cassiope lycopodioides	Clubmoss cassiope	Sensitive
Castilleja levisecta	Golden Indian-paintbrush	Endangered
Cimicifuga elata	Tall bugbane	Threatened
Fritillaria camschatcensis	Black lily	Sensitive
Galium kamtschaticum	Boreal bedstraw	Sensitive
Lobelia dortmanna	Water lobelia	Threatened
Lycopodiella inundata	Bog clubmoss	Sensitive
Lycopodeum dendroideum	Treelike clubmoss	Sensitive
Platanthera chorisiana	Choris' bog-orchid	Threatened
Platanthera obtusata	Small northern bog-orchid	Sensitive
Utricularia intermedia	Flat-leaved bladderwort	Sensitive

3.3.3 Commercial Timber Distribution

Forest stands of commercial timber age in the Cedar River Municipal Watershed are distributed in both regular and irregular patterns across the area (see Table 3.3-1). In general, the location of commercial timber stands and the remaining old growth stands in the Watershed are a result of the past history of harvest in the Watershed. The western third of the Watershed is mostly in the 50- to 100-year age classes because the earliest entries were in this readily accessible area. The central portion of the Watershed has the highest concentration of stands in the 10- to 50-year age class since these areas were next in accessibility. The eastern one third of the Watershed has the least acres entered because it is the least accessible due to elevation. This area contains the largest blocks of unharvested old growth forest and critical habitat for late successional dependent species.

History of Timber Harvest in the Watershed

The current distribution of forest stand ages has been influenced by more than 100 years of timber harvest activity. Harvesting began during the 1880s in the western lowlands around Landsburg and has generally proceeded eastward to higher elevation forests. Logging in the Watershed began in the lower municipal watershed utilizing railroad transportation systems. As roads were built to facilitate timber harvest activities from around 1940 on, truck logging replaced railroad logging.

Early harvest areas at lower elevations were usually burned after harvest. These stands typically reseeded naturally to Douglas-fir, western hemlock, western red cedar, and red alder. Shortly after 1900, the City of Seattle began exercising increased levels of control over timber activities in the Watershed and undertook active forest protection, reforestation, and other management activities. Timber harvest has been primarily by clearcutting and commercial thinning. After final harvest, areas have been managed to protect against fires and to ensure adequate regeneration. Additional information on the history of timber harvest in the Watershed is contained in City of Seattle (1998).

Time Distribution of Commercial Timber Harvest

Table 3.3-4 presents a general summary of the harvest history within the Cedar River Municipal Watershed. The distribution of the annual harvest (average volume/year) shows that the harvest was greatest between 1900 and 1923 when over 100 million board feet (MMBF) were harvested per year. The annual harvest averaged approximately 50 MMBF during the next 20-year period until 1945 when the Cedar River Logging Agreement was developed between the private timber owners and the City. This agreement established an annual allowable harvest of 35 MMBF (Pasin, 1983). This agreement remained in effect until 1989. In 1986, a moratorium was placed on timber harvesting on City owned lands from this point on.

Timber harvest in the Cedar River Municipal Watershed can be estimated between 1900 and 1985 (City of Seattle, 1998) and is shown in Table 3.3-4. The volume harvested by the various owners over the past century in approximately 57 percent by private timber companies, 33 percent by the USFS, and 10 percent by the City of Seattle.

Timber harvest around Masonry Pool and Chester Morse Lake, 1930

Regeneration harvest areas on former federal lands in the Cedar River Municipal Watershed

Timber Harvest in the Cedar River Municipal Watershed Since 1985

Table 3.3-5 shows timber harvest in the Watershed since 1985. During this period, approximately 231 acres of second growth timber has been harvested on City land in the Watershed. All such harvest was authorized by Seattle City Council ordinances. Nearly all of this timber was harvested expressly to save old growth forest, through sales to raise revenue for acquisitions, agreements to defer old growth harvest on federal land, or timber exchanges to acquire old growth from private landowners. All logging was in previously harvested, second growth forest on flat terrain away from any streams. For these harvest units, the City attempted to implement the concepts of New Forestry, developed as an alternative to tree farming (Franklin, 1989). In this approach, live trees and snags, as well as other biological legacies of the original native forest, were retained during harvest. The purpose of these harvest unit designs was to create structure in the regenerating stands similar to stands regenerated by natural disturbances, such as fire.

During the period 1985 to 1994, the USFS harvested roughly 2,500 acres prior to the exchange of final deeds.

Table 3.3-4. Summary of timber harvest within the Cedar River Municipal Watershed (all ownerships)1/

Period	Acres Harvested	Volume Harvested (MMBF)	Average Acres/Yr	Average Volume/Yr (MMBF)
Prior to 1900	2,479	Not Available	Not Available	Not Available
1900-1923	29,684	2,800	1,237	116.6
1924-1943	13,405	1,000	670	50.0
1944-1961	9,055	544	503	30.2
1962-1977	11,780	570	736	35.6
1978-1985	4,848	218	606	27.3*
TOTALS	68,772*	5,132**	800	59.7

* Includes the depressed timber market years.

** Excludes harvest prior to 1900.

1/ Information and references in Table 3.3-4 for the periods prior to 1900 to 1982 are taken from Pasin, S., 1983, "An Analysis of the Effects of Various Silvicultural Standards and Guidelines on National Forest Lands Within the Cedar River Municipal Watershed, North Bend Ranger District, Mt. Baker-Snoqualmie National Forest, in cooperation with the City of Seattle Water Department."

2/ Information for timber sales in the Cedar River Municipal Watershed between 1983 and 1985 was provided by Seattle Public Utilities.

Table 3.3-5. Estimates of timber harvest in the Cedar River Municipal Watershed 1986 through 1997

				Private	USFS	
Year	City Acres	Volume	Acres	Volume	Acres	Volume
1986	15	450 MBF	215	8,400 MBF	688	32,000 MBF
1987	22	660 MBF	88	4,000 MBF	563	19,100 MBF
1988			216	10,600 MBF	210	6,800 MBF
1989			461	20,600 MBF	223	10,600 MBF
1990	4	200 MBF	97	4,900 MBF	372	19,100 MBF
1991	46	1,800 MBF	92	2,800 MBF	211	13,100 MBF
1992	93	4,000 MBF	132	4,100 MBF	94	6,400 MBF
1993					18**	900 MBF
1994	44	1,900 MBF			17**	900 MBF
1995	*	400 MBF				
1996	*	200 MBF				
1997	7	120 MBF				

* Salvage in previous units

** 1993-94 USFS completed two units totaling approximately 35 acres and 2 MMBF.

Remaining Old growth Forest

After about a century of logging in the Watershed, a little less than 14,000 acres of original, native forest remains. Some of this forest would meet the ecological definition of old growth forest (Franklin and Spies, 1983). All of this native forest is more than 190 years old, and some approaches 800 years old. Most of this original native forest was generated by large-scale forest fires that occurred in the region about 350 and 700 years ago.

3.3.4 Current Management and Silvicultural Practices

Secondary Use Ordinance (City of Seattle Ordinance #114632)

The current timber management program for the Cedar River Municipal Watershed is directed and regulated by Ordinance 114632, called the Secondary Use Ordinance. Ordinance 114632 (Technical Appendix 12) was based on the Secondary Use Analysis EIS (Seattle Water Department, 1990) and the recommendations made by a 17-member advisory committee. It was approved in 1989 by the Seattle City Council after an additional 8-month public review period.

The Secondary Use Ordinance directed the Seattle Water Department (now Seattle Public Utilities), as a primary objective, to manage the Cedar River Municipal Watershed to ensure the supply of high quality drinking water without requiring additional treatment. Policies directed the City to manage the resources of the Watershed as necessary to protect water quality and use "best management practices" in areas designated for planned commercial timber harvest. The Ordinance also directed the Utility to pursue acquisition of remaining federal land in the Cedar River Municipal Watershed, to negotiate with the USFS to acquire and preserve old growth and special resource areas, protect wildlife habitat, protect and enhance fisheries habitat, improve deterrents to trespass, develop timber commercial timber harvest program and develop public education program.

The ordinance also directed the Seattle Water Department to develop a long-term timber harvest program which would provide the economic resources to acquire and preserve old growth and other special resources. Under Policy #6-9 of the ordinance, all revenues generated from the sale of City-owned second growth timber in the Watershed were restricted as follows:

> "Until the Council approved land and habitat acquisition program in the Cedar River Municipal Watershed is completed, all net revenues from commercial thinning, salvage, and timber harvest will be used only to support the land and habitat acquisition program."

This policy allowed the City to protect old growth habitat as well as to acquire habitat over the past 8 years, as described above. Presently, the applicant owns and manages all of the forest lands in the Watershed as a result of the land exchange completed with the USFS. As a result, the Cedar River Watershed HCP is intended to replace these policies for long-term forest management in the Watershed.

3.3.5 Silvicultural Practices

The practice of silviculture takes into account the interaction of soils, climate, and tree physiology in determining how a stand of trees is tended, harvested, and regenerated. Silvicultural practices are directed at creating and maintaining the type of forest that will meet specified management objectives. Silvicultural prescriptions for timber harvest are developed based on examination of a particular site and consideration of the management objective.

Prior to 1974, harvest practices on federal and private lands were mostly regeneration cutting by clearcut methods, with little or no restrictions for riparian, wildlife, and other resources protection. Since 1974, silvicultural practices in the Watershed focused primarily on managing the different ownership parcels under the Mt. Baker-Snoqualmie National Forest Land and Resource Management Plan for the federal lands and the Washington Forest Practices Management Act for the privately owned lands.

Since the adoption of the Secondary Use Ordinance, significant changes took place in the way the timber has been harvested in the Cedar River Municipal Watershed. As opposed to standard regeneration clear cutting typically found on industrial forest lands, the City of Seattle began a forestry program in 1990 aimed at perpetuating and restoring the complexity of the natural forest ecosystem. Techniques referred to as “bioforestry” or “new forestry” were developed to allow the commercial harvest of timber while retaining the natural diversity of affected forest stands to integrate harvest units into the habitat mosaic of the whole Watershed.

In general, bioforestry strategies have focused on retaining green trees, dead trees, logs, and other elements of biological and structural diversity. Silvicultural practices implemented during the 1990s were designed to provide both short- and long-term benefits to selected wildlife and ecological processes. Following harvests, stands have been planted with a variety of trees. Selective thinning in the future should create a harvestable, mixed forest with large and small trees, standing dead and downed trees, and a multilayered canopy with late successional forest habitat characteristics.

In order to achieve the above objectives, the approaches to recent harvesting have varied depending upon specific site characteristics. For example, on one 40-acre harvest unit, a peninsular aggregated design was employed. In this design, the unit was divided into wedges like slices in a pie and wedges of harvest were alternated with wedges of leave areas. Overall, about 20 percent of the forest cover was retained. Within harvest areas, green trees, snags, and logs were retained. Some thinning was done in the leave areas, and live trees

“Bio-forestry” timber harvest unit in the Cedar River Municipal Watershed

were topped or cut to try to create snags and provide downed logs. Another example is the application of dispersed green tree retention on sites with relatively low blow-down potential. On one 49-acre unit, an average of 12 trees per acre were left scattered fairly evenly throughout the site. In this case, retained trees were selected based on a variety of factors including size, age, species, and foliage.

Washington State Forest Practices Act

The Washington State Forest Practices Rules and Regulations are the principal means of State regulation of forest management activities in the Cedar River Municipal Watershed. These regulations and rules set standards and operational constraints on forest management activities such as timber harvesting, reforestation, and road construction and maintenance. There are four classes of forest practices created by the Act. Class I forest practices are those determined by the State to have no direct potential for damaging public resources. Class II practices may involve practices which have been determined to have less than ordinary potential to damage public resources. Class III forest practices cover most typical timber harvesting and road construction activities. Class IV special forest practices require an environmental checklist in compliance with the State Environmental Policy Act and SEPA guidelines. Class IV special forest practices are those which have potential for a substantial impact on the environment. These include such practices as road construction or timber harvest on slide prone areas in watersheds that have not undergone a Watershed Analysis under 222-22 WAC. Other provisions of the rules regulate management activities which may impact critical wildlife habitats.

Road Maintenance and Silvicultural Practices Road Maintenance

Maintenance of the existing transportation system within the Cedar River Municipal Watershed is essential to maintain access for protection of wildlife habitat, timber management, recreation, protection of fisheries habitat, and scientific research and cultural resources as required under the Secondary Use Ordinance. In addition to the Secondary Use Ordinance which requires the use of best management practices, road maintenance is regulated by the WDNR. WAC 222-24-010 states in part: "A well designed, located, constructed, and maintained system of forest roads is essential to forest management and protection of public resources." The WDNR defines public resources to include water, fish, and wildlife in addition to capital improvements.

The Secondary Use Ordinance and WAC 222-24 provides the regulatory framework for road maintenance and new construction within the Cedar River Municipal Watershed. Additionally, the City is required to provide a road maintenance and abandonment plan to the WDNR on or before June 30th of each year. This plan must include maintenance of active roads, maintenance of inactive roads, culvert replacement, upgrade, or maintenance, abandonment of roads, brush control, and road surface treatment. The WDNR road maintenance and abandonment plan is essentially a series of best management practices for roads within the Cedar River Municipal Watershed. The road maintenance and abandonment plan shows on an annual basis how we implement the Transportation Plan that is referenced in Appendix 17 of the HCP. The Transportation Plan is our existing road maintenance and improvement practices, which we are legally required to perform, according to WDNR regulations. The annual road maintenance and abandonment plan must also meet the Secondary Use Ordinance requirements of preservation and enhancement of fish habitat. The City has already abandoned approximately 19 miles of roads and replaced, upgraded, or installed approximately 250 culverts in compliance with the Secondary Use Ordinance to reduce the amount of coarse and fine sediment entering fishery streams from roads. Future funding for continued implementation of these efforts is uncertain.

3.3.6 Silvicultural Systems

The most common silvicultural prescriptions found in the western Cascades are described in the following subsections.

Regeneration Harvest

A general term for silvicultural systems that involve removal of most trees within a harvest area for the purpose of stand regeneration. (Regeneration harvest systems return the stand to an early stage of forest succession). Such systems are commonly used for commercial timber harvest in the Pacific Northwest and include clearcutting, shelterwood harvest, seed tree harvest, and retention harvest (see definition).

Retention Harvest

As used in this HCP, a type of regeneration harvest applied on non-reserve lands (matrix lands - those available for commercial harvest). Compared to traditional clearcutting, retention harvest entails retaining more trees per acre than required by Washington State Forest Practice Rules. As applied in the HCP, the intent of this method is to achieve an average 20 percent volume retention goal that includes retaining biological legacies such as remnant older trees, other green trees, previously unmapped forested wetlands, and inoperable patches of forest. Retention harvest also focuses on protection of other biological legacies, such as shrubs, snags, logs, understory vegetation, and soil microorganisms. This harvest is intended to provide revenue while promoting structural and biological diversity characteristic of naturally regenerated stands.

Restoration Thinning

As used in this HCP, a silvicultural intervention strategy applied in the Ecological Reserve in areas of young (usually 10 to 30 years old) overstocked forest with the intent of increasing biological diversity and wildlife habitat potential, accelerating the development of mature forest characteristics, and minimizing the amount of time a stand remains in the stem exclusion stage (a stage characterized by minimal light penetration and low biological diversity). This strategy protects water quality by reducing the risk of large-scale catastrophic damage to the Watershed (primarily through development of windfirmness and increased resistance to insect attack, which is exacerbated by the stress on intense competition among trees). Techniques for restoration thinning include cutting, girdling, or otherwise killing some trees in variable density thinning patterns, retaining a mix of species that is characteristic of natural site conditions, and leaving small gaps or openings characteristic of naturally regenerated forests that result from small natural disturbances such as wind or disease.

Precommercial Thinning

A silvicultural treatment applied on Matrix lands (those available for commercial timber harvest) that involves cutting, girdling, or otherwise killing excess trees from young (usually 10 to 30 years old), overstocked stands to reduce competition and encourage better growth. This silvicultural practice also accelerates the development of mature stand characteristics, reduces the amount of time a stand remains in the stem exclusion stage (a stage characterized by minimal light penetration and low biological diversity), protects water quality by reducing the risk of large-scale catastrophic damage to the Watershed (primarily through development of windfirmness and increased resistance to insect attack), and improves overall health and vigor of the leave trees. Precommercial thinning is used to produce, over time, an increase in the stand's usable volume in preparation for commercial harvest.

Commercial Thinning

As used in this HCP, the silvicultural practice applied on Matrix lands (those available for commercial harvest) that removes excess trees from overstocked, merchantable second growth stands (usually over 30 years old), including the removal of weak, diseased, and dying trees. The primary intent of this practice is to provide revenue while maintaining or improving the growth, health, and windfirmness of the leave trees by ensuring adequate growing space and crown area, and improving stand vigor. Compared to conventional commercial thinning, the commercial thinning described in this HCP will also have the objectives of developing a high level of vertical and horizontal stand structure, accelerating development of mature stand characteristics, developing a heterogeneous understory, and recruiting large snags and downed logs as coarse woody debris in older stands. These stand characteristics will be fostered by multiple thinning entries and longer (120 to 140 years) regeneration harvest rotations.

Ecological Thinning

As used in this HCP, the experimental silvicultural practice applied in the Reserve of cutting, damaging, or otherwise killing some trees from some areas of older, overstocked, second growth forest (typically over 30 years old). The intent of ecological thinning is to encourage development of the habitat structure and heterogeneity typical of late-successional and old growth stands, characterized by a high level of vertical and horizontal stand structure, and to improve habitat quality for wildlife. It is expected that techniques will include variable-density thinning to create openings, develop a variety of tree diameter classes, develop understory vegetation, and recruit desired species; and creating snags and logs by uprooting trees, felling trees, topping trees, injecting trees with decay-producing fungus, and other methods. Ecological thinning does not have any commercial objectives. However, in those cases in which an excess of woody material is generated by felling trees, trees may be removed from the thinning site and may be sold or used in restoration projects on other sites.

Shelterwood

This is practice of harvesting an area with two or more removals over time to ensure regeneration. This system provides seed for natural regeneration and the residual trees protect seedlings from extreme heat and frost. Residual trees are harvested as soon as restocking goals are met. Advantages of this prescription include better control of stand composition and control of site conditions to minimize weather damage.

Single Tree or Group Selection

Individual trees or small groups of trees of all ages are removed to create a mosaic of uneven-aged groups. Groups range from 0.1 acre to approximately 5 acres in size.

Timber Harvest Methods

Topography and the size and weight of logs dictates the type of equipment used to move trees from where they are felled to a landing or road where they can be loaded onto a truck. The term “yarding” is used for the process of moving logs from the stump to the landing or road with cable. Flatter areas are generally skidded using rubber-tired tractors to ground-skid logs from where they have been cut. Hillside or steep areas are generally yarded using short-span (1,000 to 2,000 foot reach) elevated cable systems designed to lift one end of the log off the ground and drag it to the landing. Cable yarding systems generally have less impact on soils than ground skidding, but may require more road building. In the Watershed, minimal new road construction will be required due to the existing road network. Both logging systems are used in a variety of applications that are site specific. Ground skidding traditionally has allowed harvesters to remove selected trees, while leaving some or many of the other trees in the stand. Improved equipment design and engineered cable systems also allow more selective removal with cable yarding machines.

For the past 30 years, timber harvest methods in the Watershed have included ground-based and cable-based yarding systems. Since 1962, as logging began to occur more frequently on steeper portions of the Watershed, 95 percent of the logging has been accomplished with the highlead and shotgun (flyer) cable systems. Skyline cable logging systems which suspend one or both ends of the log during yarding have been used to a very small degree. In contrast, ground-based systems have been used on less than 5 percent of the area harvested in the Watershed. Helicopter yarding systems have not been used in the Watershed.

Skyline cable logging system in green tree retention harvest unit

3.3.7 Summary

This section has described the current distribution of forest seral stages and forest stand ages. This information will be used in Section 4.3 to evaluate the environmental consequences of the alternatives. Specifically, the amount and seral stage of forests placed in Reserves, the amount and seral stages of forests available for timber harvest, how timber harvest prescriptions affect the structure of the forest, and the volume of timber available for harvest will be discussed. This information is also important for the evaluation of the effects of alternatives on soils (Section 4.1), water quality (Section 4.2), fisheries (Section 4.4), wildlife (Section 4.5), and socioeconomics (Section 4.11).

3.4 Fisheries Habitat and Resources

This section describes the fisheries resources and their habitats within the Cedar River Basin. The information will be presented in two primary sections. The first section describes the species found in the Basin, their current population status (including ESA status) and distribution, and a description of their life histories. The second section discusses fish habitat in the Basin and its current condition. The descriptions are intended to provide the decision-maker and the public with enough information to understand the discussion of the likely impacts presented in the Environmental Effects section. Some subjects will be discussed very generally, while others will include specific information. Much of the following information is presented in more detail in the City of Seattle's Draft HCP (City of Seattle, 1998).

A wide variety of fish occur in the Cedar River Basin. The discussion below will focus primarily on the species targeted for protection and mitigation under the proposed HCP: chinook salmon, coho salmon, sockeye salmon, steelhead trout, bull trout, pygmy whitefish, and resident rainbow and cutthroat trout.

Section 3.4.1 describes the life histories of the species found in the Cedar River Basin and the types of habitat used during their lives. All of the species mentioned above are in the family Salmonidae and have many similarities in their life histories. The differences in the life histories are important for understanding the effects of the different alternatives. For anadromous fish, the duration and habitat used during their freshwater rearing period are particularly important. Section 3.4.2 describes the fish habitat found in the Cedar River Basin, the factors that determine its quality, and its current condition. It also discusses the physical factors the applicant can influence through its management. Habitat characteristics and conditions within the Municipal Watershed, as well as the mainstem Cedar River downstream of the Landsburg Diversion Dam are described. Discussion of how the operation of Chester Morse Lake, Masonry Pool, and the Landsburg Dam influence fish habitat is provided. Their operation influences reservoir levels and instream flows below Masonry Dam. Section 3.4.2 also provides a synopsis of the sockeye salmon mitigation goals for 12.4-mile mainstem reach of the Cedar River between Cedar Falls and Landsburg Diversion. A brief summary of the primary considerations used in the alternative analysis presented are provided in Section 3.4.3.

3.4.1 Fish Resources and Distribution

Historically, anadromous fish migrated to the Cedar River via the Duwamish and Black Rivers. Using other sources, Cascade Environmental Services (1991) summarizes the species suspected to have once occurred in the Cedar River. Chum salmon (Oncorhynchus keta), pink salmon (O. gorbushca), sockeye salmon (O. nerka), coho salmon (O. kisutch), chinook salmon (O. tshawytscha), and steelhead trout (O. mykiss) were present to some degree in the Cedar River prior to 1916. The historic upstream extent of these species is unclear, but, prior to the installation of the Landsburg Diversion Dam in 1916, coho salmon, chinook salmon, and steelhead trout were believed to have used the Cedar River and accessible tributaries up to Cedar Falls, which is a natural passage barrier. An impassable waterfall barrier near its confluence with the Cedar River precludes use by anadromous fish in the Taylor Creek drainage as well. Nonanadromous salmonids occur throughout the upper Cedar River and Taylor Creek Watersheds upstream of natural barriers (see Map 7).

The portion of the Watershed owned by the City of Seattle and managed by SPU, referred to as the Cedar River Municipal Watershed, is currently inhabited by nonanadromous salmonids. Stream resident cutthroat trout (O. clarki) and rainbow trout (O. mykiss) inhabit the Taylor Creek basin. Rainbow trout and cutthroat trout occur in the Cedar River and most tributaries between the Landsburg Dam and Masonry Dam , with rainbow trout the predominant in the mainstem Cedar River and cutthroat are predominant in the smaller streams. Upstream of the Masonry Dam, the upper municipal watershed includes stream resident populations of rainbow trout (Oncorhynchus mykiss), as well as adfluvial forms of bull trout (Salvelinus confluentus), rainbow trout, and pygmy whitefish (Prosopium coulteri) that migrate from Chester Morse Lake to spawn in tributary rivers and streams. No cutthroat trout are reported to occur in the Municipal Watershed upstream of Masonry Dam.

The status and life history strategies of salmonids that are considered at-risk species on a list of species of concern in the Cedar River are described in detail within the proposed HCP (City of Seattle, 1998). A basic understanding of the life history of these species is important for recognizing and understanding the likely impacts associated with different proposed alternatives in later sections of this EA/EIS. Differences in life history traits may mean that mitigation that is likely to be effective for one species may not be effective for another. Similarly, differences may mean that the risks associated with one form of mitigation may be high for one species, but low for another. The following is not intended to be a detailed description of the life history of the Pacific salmon and trout, but is intended to highlight traits important to understanding the mitigation strategies in the alternatives discussed in the Environmental Effects section (Chapter 4.4).

Anadromous Fish Species of Concern

Chinook, coho, and sockeye salmon and steelhead trout are currently found in the Cedar River subbasin upstream to the blockage at Landsburg Dam. The life histories of the anadromous fish species in the Cedar River are similar in many aspects, but important differences are also present between the species. All of the species spawn in freshwater; juveniles migrate to the ocean and rear for a period of time, then return to their natal stream to reproduce. The timing of spawning and the duration of rearing in the Cedar River varies among the species (Figure 3.4-1).

Chinook Salmon

The chinook salmon (Oncorhynchus tshawytscha) is the largest of the seven species of Pacific salmon.[1] Mature adults can reach weights in excess of 40 kilograms (kg). Chinook are the least numerous of the five Pacific salmon species that occur in North America. In the eastern Pacific, spawning populations range from the central coast of California, north to the drainages of Kotzebue Sound.

According to Washington Department of Fisheries and Western Washington Treaty Tribes (1993), there are 26 stocks of chinook salmon in Puget Sound. At the time of their report, the authors classified the population status of approximately half of the stocks as depressed. However, since that time, there has been a sharp decline in the abundance of Puget Sound chinook, and nearly all naturally reproducing populations in the area are now considered depressed (Johnson et al. 1997; Smith, WDFW, personal communication, 1998).

Stock Origin and Current Status

The Lake Washington watershed has a long history of being stocked with hatchery reared salmonids (Ajawani, 1956). Today, the majority of chinook salmon returning to the basin originate from the Issaquah and University of Washington hatcheries. Hatchery-reared chinook were planted in the Lake Washington basin as early as 1914 (Darwin, 1916). Ajawani (1956) reported extensive plantings of Issaquah and Green River hatchery chinook into Cedar River during the period from 1943 to 1954. According to a 1948 Washington Department of Fisheries (WDF) report, salmon returns to the Cedar River were at one time negligible, but were significantly enhanced by plantings from the Issaquah and Green River hatcheries (WDF, 1948). Like many early artificial production programs, the effectiveness of this planting program was not rigorously monitored. Therefore, it is difficult to confirm the former status of salmon in the Cedar River. Currently, there are no releases of hatchery chinook into the Cedar River.

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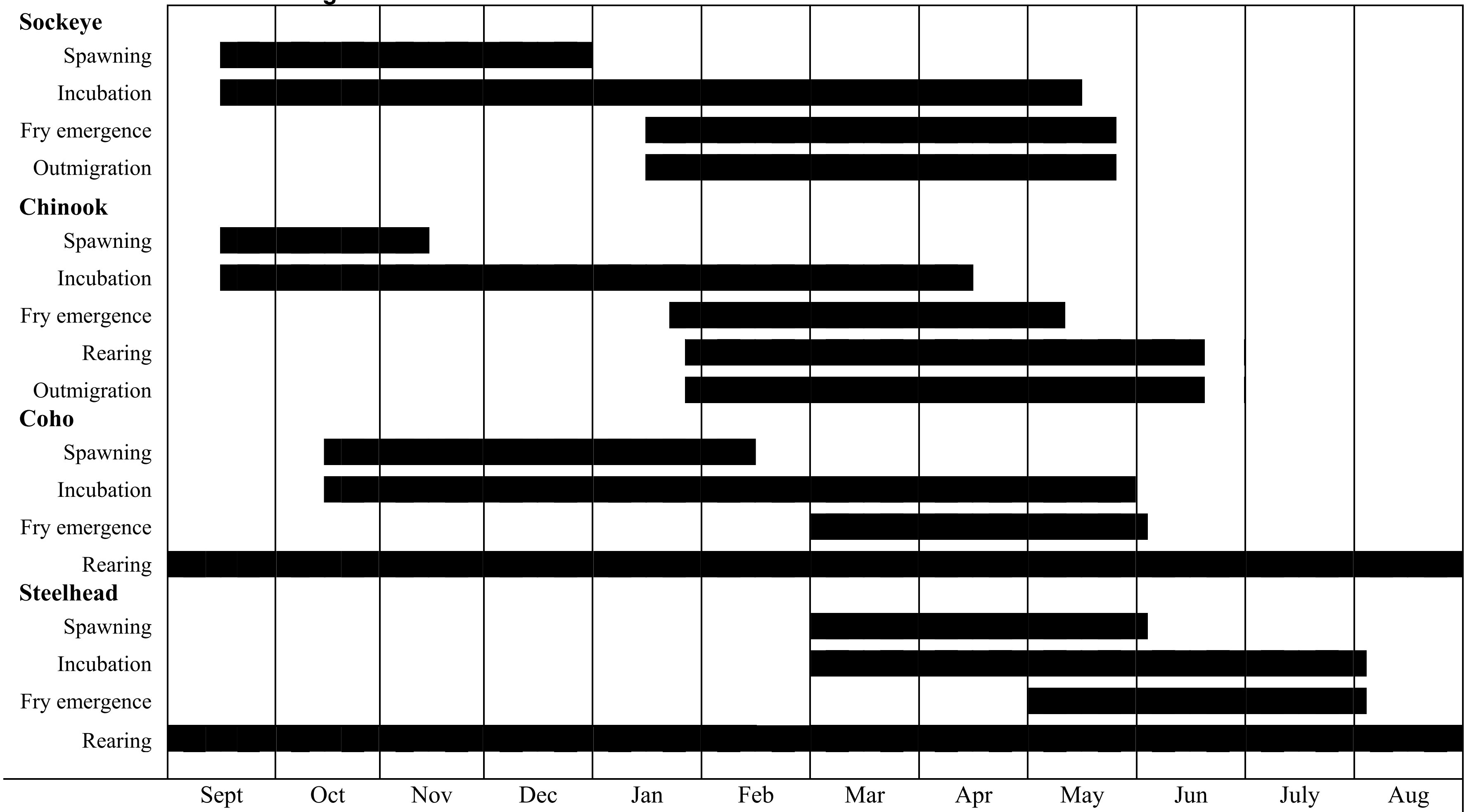
[1] Rainbow and cutthroat trout are now included in the genus *Oncorhynchus*. For convenience, we follow the convention of Groot and Margolis (1991) to maintain the common distinction between salmon and trout and do not include these two species when referring to the seven species of salmon in the Pacific basin.

Figure 3.4-1. Approximate life history timing of sockeye, chinook, and coho salmon and steelhead trout in the Lake Washington watershed



The Washington Department of Fisheries and Western Washington Treaty Tribes (1993) classified the status of Lake Washington chinook salmon as unresolved due to differing viewpoints of state and tribal resource managers. Johnson et al. (1997) describe wild Puget Sound chinook as relatively stable from 1968 to 1990 with a sharp drop in abundance.

Puget Sound chinook salmon, including the populations in the Lake Washington Basin, were recommended for listing as threatened under the federal Endangered Species Act on February 26, 1998 (Federal Register [FR] Vol. 63, No. 45, March 9, 1998).

Life History Overview

Like all eastern Pacific salmon, chinook are anadromous, they return to their natal streams to spawn, and they are semelparous (die after spawning). In an extensive review of the literature, Healey (1991) used differences in life history patterns to divide eastern Pacific chinook salmon into two broad races: stream-type populations and ocean-type populations. While there is significant variation in specific life history patterns between and within stocks in each race, it is possible to discern broad, general patterns unique to each race. In North America, spawning populations of stream-type chinook are predominant north of latitude 56^{o}N and in headwater areas of large river systems throughout the species' range. Ocean-type populations predominate south of latitude 56^{o}N, except in headwater areas of large river systems. Table 3.4–1 summarizes the key life history attributes of each race. Note that stocks in the extreme south and north of the chinook's range may depart somewhat from this general model (Kjelson et al., 1982; Hallock and Fry, 1967; Yancey and Thorsteinson, 1963).

Cedar River chinook appear to be relatively well-matched with the description for ocean-type chinook. Their natal stream is located well south of 56^{o} N, but is still within the central portion of the range of eastern Pacific chinook populations. Adult chinook enter Lake Washington through the Ballard Locks from late June through September with a peak in late August (Warner, 1998, personal communication). They spawn from early to mid-September through mid- to late November with a peak in early to mid-October (CES, 1995; WDF et al., 1993).

Spawning populations of ocean-type chinook are not commonly found above large natural lakes. Although there are a few examples of chinook spawning upstream of natural lakes in this region (e.g. Nanaimo River, Vancouver Island), most of these populations are thought to exhibit the stream-type life history and use the lakes primarily as overwintering habitat (Carl and Healey, 1984; Healey, 1980, 1982). The position of Lake Washington between the Cedar River and the marine environment raises some interesting questions regarding the ocean-type life history pattern and is discussed later.

Table 3.4-1. Comparison of the life history characteristics of stream-type and ocean-type races of eastern Pacific chinook salmon (summarized from Healey 1991).

Life History Stage	Stream-type	Ocean-type
Spawning migration	Enter rivers in spring and early summer and may hold in fresh water for up to several months before spawning.	Enter fresh water in summer and fall and spawn shortly after entry into fresh water.
Spawning	Spawn in summer and fall.	Spawn in fall and early winter.
Juvenile rearing	Rear in fresh water for at least one full year. Move through the estuary fairly quickly as yearling smolts and into near-shore areas of the marine environment.	May move directly downstream to estuary immediately after emergence in the spring; or may rear in streams for up to three months. Rear in estuary for up to several months before dispersing into near-shore areas of marine environment.
Adults at sea	Move rather quickly through the near-shore areas and into the open ocean where they tend to exhibit extensive migrations in the North Pacific Ocean.	Tend to remain in continental shelf waters and typically range less than 1,000 km from natal stream.

Spawning

Chinook spawning behavior is similar to that of other salmonids. The female selects an appropriate spawning location over gravel and small cobble substrate where she excavates the redd. Chinook salmon enter the Cedar River early-September through mid-November (CES, 1991). Chinook spawn soon after entry into the river with the peak spawning period usually occurring in early to mid-October. Most spawning currently occurs in the mainstem of the Cedar River downstream of Landsburg, with limited use of the larger tributary streams below the Diversion Dam.

Incubation and Early Rearing

Chinook eggs in this region typically hatch 2 or 3 months after fertilization. The larval fish, or alevins, remain in the gravel for an additional 2 or 3 months, then emerge into the stream as free-swimming fry. There is little data on the precise development rate and emergence timing of Cedar River chinook. In the Cedar River, fry probably begin to emerge in February and continue through March and perhaps April.

Chinook fry typically emerge at night and tend to exhibit an immediate downstream dispersal (Reimers, 1971; Healey, 1980; Kjelson et al., 1982). Within the ocean-type race, Healey, (1991) distinguishes two life history variations: (1) fry that emerge from the gravel, disperse downstream to the estuary in a matter of hours or days where they then rear for an extended period; and (2) fry that emerge, disperse a shorter distance downstream, then stop and rear in the river for up to 3 months before migrating downstream to the estuary for another period of extended rearing. In several well-studied rivers in southern British Columbia, the movement of newly emerged fry to the estuary typically occurs from early March through early May. A second migration of fry that have reared in the river and are approximately twice the size of the early migrants occurs from mid-May to mid-June (Healey, 1991). The degree to which Cedar River chinook exhibit these two alternative behaviors at emergence is not known. Although extensive surveys have not been conducted, juvenile chinook have not typically been found in the Cedar River after mid-summer. In addition, the distribution and behavior of chinook fry in Lake Washington and the role that the lake plays as a rearing area and migration corridor are not well understood.

Distribution in the Marine Environment

Healey (1991) cites a large number of studies that have reported the importance of estuaries as rearing habitat for ocean-type chinook. The behavior and distribution of juvenile Cedar River chinook, after they have migrated through the Ballard Locks and into salt water, has not been studied.

No data are available on the specific distribution of Cedar River chinook in Puget Sound or the North Pacific. However, harvest data for the Green Hatchery stock indicate that nearly all fish that are taken in sport and commercial fisheries are harvested off British Columbia, the coast of Washington, and in Puget Sound. Less than one percent of the fish are harvested off the coast of Alaska (Pacific Salmon Commission, 1996). This information suggests that the ocean distribution of Cedar River chinook is likely similar to that described by Healey (1991) for ocean-type populations in this region.

Habitat Characteristics and Key Factors Affecting Survival

There are a number of factors that have affected the survival of Cedar River chinook salmon, including loss and degradation of stream habitat due to a variety of land and water management practices; predation by native and introduced species in the river and lake; injury to juvenile fish exiting the lake via the Ballard Locks; droughts; floods; overharvest; and unfavorable ocean conditions. All of these effects should be viewed in the context of what may have been the most significant single anthropogenic effect on the ecosystem, the alteration of the basin's hydrologic configuration.

Between 1912 and 1917, the hydrology of the Cedar River and Lake Washington was dramatically altered when the Cedar was rerouted into the lake and the outlet of the lake was rerouted through the Ballard Locks to Salmon Bay.

The effects on Cedar River chinook of rerouting the river into Lake Washington are difficult to ascertain but potentially quite profound. The lake provides a much different migration environment for recently emerged fry than the original river environment. Although the lake could potentially provide rearing habitat for newly emerged chinook fry, it is not clear to what degree ocean-type chinook possess the adaptive capacity to make use of a lake-rearing environment. It is also difficult to quantify the quality of this environment, which has been subjected to extensive shoreline development and is home to a host of introduced species that can prey on young chinook. The requirement for young ocean-type chinook to migrate through Lake Washington could limit the productive capacity of the population.

The highly modified environment at the marine-freshwater interface downstream of the Ballard Locks poses an additional puzzle. This environment is much different than the natural estuary that was present at the mouth of the Duwamish River. Numerous sources as cited by Healey (1991) have reported on the importance of estuarine rearing for juvenile ocean-type chinook salmon. The behavior, growth, and survival of juvenile ocean-type juvenile chinook in the ship canal downstream of the Ballard Locks has not been well studied. However, it seems clear that this environment provides far less favorable conditions than the original estuary at the mouth of the Duwamish River.

Coho

The coho salmon (*Oncorhynchus kisutch*) is one of the most popular sport fishes in the family Salmonidae. For most of the twentieth century it has been the mainstay of the average west coast salmon fishing trip. Coho salmon occur along the Pacific coast from Monterey Bay, California, northward to Point Hope, Alaska (Wydoski and Whitney, 1979). The typical size of adult coho salmon in the Lake Washington basin is between 4 and 7 pounds, although fish as large as 10 pounds have been observed. The largest coho in the state weighed 21 pounds, but in recent years large coho have been rare.

The population of coho salmon in the Cedar River is somewhat unique and is defined by the timing of their spawning (late October to late February) as well as their geographic separation from other significant coho streams in the drainage (WDF et al., 1993). It is unknown how spawner interchange or differences in off-station planting has influenced the Cedar River subpopulation. Until a genetic evaluation is made of the various subpopulations in the basin, designations between Cedar River spawners and other geographical groups are tentative.

Stock Origin and Current Status

The coho population in the Lake Washington watershed is comprised of both natural and hatchery subpopulations. Significant releases of hatchery yearlings were made from the early 1950s to the early 1970s, and regular fingerling and fry plants were made from the mid-1970s to the present. These releases have included coho salmon from the Minter, Green, and Skykomish rivers. There are also annual yearling releases from the Issaquah Creek Hatchery and the University of Washington.

Natural spawning populations of coho salmon are common in tributaries to Lake Washington and the Cedar River, including the Lake Walsh subbasin. The extent of historical and current mixing between hatchery coho and wild spawning populations, both spatially and temporally, is unknown. As a result of this uncertainty, the two stocks in the Lake Washington basin are designated as mixtures of native and nonnative stocks (WDF et al., 1993).

Coho populations in the Lake Washington basin have undergone significant declines in recent years. Coho escapement peaked at over 30,000 fish in 1970, but declined to less than 2,000 fish in 1992 (Fresh, 1994; King County, 1993). The desired escapement for Lake Washington is 15,000 fish, which has not been achieved since 1979.

With continued low returns of coho salmon over the past 7 years, harvests in the Lake Washington basin and the Cedar River have continued to decline. Recreational fishing on the Cedar River is currently closed and is not expected to fully reopen until significant improvements in returns of all anadromous salmonids are reported. The current outlook for the population is one of continued decline.

Although the status of Cedar River coho salmon was determined to be healthy in 1992 (WDFW et al., 1993), this assessment acknowledged that the stock would fall into the depressed classification if future returns similar to those in 1991 are observed. Due to the continuation of the downward population trend (Fresh, 1994; King County, 1993), coho salmon are now considered depressed in the Cedar River and elsewhere in the Lake Washington basin.

In response to a petition to list coho salmon under the ESA, the National Marien Fisheries Service (NMFS, 1995) completed a comprehensive status review of coho salmon along the west coast of the United States. The status review identified six populations of coho within this range. Because coho from Puget Sound and the Strait of Georgia formed a coherent genetic cluster, it was determined that this population was unique. This population includes coho from Lake Washington and the Cedar River. In comparison to other populations along the California and Oregon coasts, NMFS determined that coho salmon in Puget Sound and the Strait of Georgia were generally stable and a listing was not warranted. However, because of limited information regarding the health of this population and definitive information on the risks to naturally reproducing fish, NMFS decided to add the Puget Sound/Strait of Georgia population to the federal list of candidates for threatened and endangered species. Upon reevaluation at any time, NMFS may reconsider the present candidate listing and propose to list the Puget Sound/Strait of Georgia population as threatened or endangered.

Life History Overview

Like all eastern Pacific salmon, coho are anadromous and return to their natal streams to spawn. Coho salmon have one of the more predictable life histories of the Pacific salmon. Juveniles spend approximately 18 months in freshwater and go to sea after their second spring. After growing to maturity in the ocean, they return to their natal streams after 18 months.

Upstream Migration and Spawning

Adult coho typically begin returning to Lake Washington through the Ballard Locks in late August and continue through early to mid-November (Warner, E., Muckleshoot Indian Tribe, 1998, personal communication). After entering Lake Washington, most coho will remain in the lake for several weeks if river flows are low.

When river flows rise with fall rain, coho begin to stage at the mouth of the Cedar River. If flows continue to stay high, coho will move upstream and locate preferred spawning habitat in small tributaries with adequate gravel. Cedar River coho are thought to begin spawning in mid-October and continue into February (CES, 1991).

Incubation and Early Rearing

The specific development rate and emergence timing of Cedar River coho has not been well documented. In most coho populations in this region, eggs hatch in about 2 to 3 months. Alevins remain in the gravel for an additional 2 to 3 months sustained by their yolk sac (Sandercock, 1991). Coho fry probably begin to emerge from the gravel in early March and continue through late May with peak emergence in mid-April.

Juvenile coho rear in freshwater for at least 1 year. After a short period of schooling behavior immediately after emergence, Coho fry become very territorial and typically maintain distinct feeding territories during daylight hours (Sandercock, 1991). Some coho may remain in the same tributary for a full year before they migrate downstream. Others may migrate downstream to larger streams or possibly to the lake to continue rearing prior to smoltification the following spring. However, the role of Lake Washington in juvenile coho rearing and migration is not well understood.

After rearing for approximately 1 year in fresh water, most juvenile coho undergo the process of smoltification and migrate to salt water. Specific size data on Cedar River coho smolts is not presently available. Coho smolt out-migration has not been extensively documented, but typically occurs from late April through early July, with peak migration occurring in mid- to late May (Goetz et al., 1997).

Distribution in the Marine Environment

Once in the marine environment, coho from the Cedar River are assumed to undergo migrations similar to other coho from the Puget Sound region. This migration takes coho primarily northward into the coastal waters of British Columbia. Coho salmon released from Puget Sound are recovered in Washington, British Columbia, and Oregon, with essentially no recoveries from Alaska or California (NMFS, 1995).

Habitat Characteristics and Key Factors Affecting Survival

Coho salmon are native to the Cedar River and may have been present in Lake Washington tributaries prior to the turn of the twentieth century. However, it is unclear to what extent anadromy existed in Lake Washington and its tributaries as a result of the Lake's outlet connection to the Black River. The response of the original population of coho salmon in the Cedar River to the rather dramatic changes in the hydrology of the Lake Watershed in the early twentieth century is not known. It is not clear to what degree the present Cedar River coho population is derived from the original population that eventually found their way back to the river. Nor is it known if strays from other nearby systems or from past plantings of hatchery fish have contributed significantly to the present day population. Regardless of the source, a naturally reproducing population of coho salmon has evidently persisted in this altered environment.

There are a number of factors that can potentially affect the survival of Lake Washington coho salmon at various stages of their life history. These factors occur in both the fresh water and marine environment. Factors in fresh water include habitat loss and degradation (Scott et al., 1986), predation, droughts, floods (NMFS, 1995), and injury or mortality at the Ballard Locks (Goetz et al., 1997). Factors in the marine environment include predation, unfavorable ocean conditions, and harvest (NMFS, 1995). Although sport and Tribal harvests in Lake Washington are typically well controlled to ensure an adequate escapement, there is less control of Cedar River coho salmon harvests in Puget Sound and Canadian stock fisheries.

Sockeye Salmon

General Description

The sockeye salmon, *Oncorhynchus nerka*, is a common and relatively well studied species of the family Salmonidae. The sockeye is the third most abundant of the seven species of pacific salmon and has been targeted in major commercial fisheries for most of the twentieth century. Spawning populations of sockeye have been reported from the Sacramento River in the south to the rivers of Kotzebue Sound in the north, and east to basins that drain into the Sea of Okhotsk (Burgner, 1991). Size at maturity varies considerably between and within populations of sockeye, with larger fish typically spending additional time at sea. The average weight of sockeye returning to the Cedar River is approximately 5.25 pounds (James M. Montgomery Inc., 1990).

Sockeye Salmon

Sockeye salmon are the most numerous naturally reproducing salmonids in the basin and, in years of high abundance, the population has supported a significant Tribal treaty harvest and one of the largest sport fisheries in the state (Fresh, 1994). The migration of sockeye through the fish ladder at the Ballard Locks attracts thousands of visitors each year. The observation of spawning sockeye in the Cedar River, Bear Creek, and Issaquah Creek has become a popular fall outdoor recreation activity for many people in the region.

The majority of sockeye returning to Lake Washington spawn in the Cedar River. The north Lake Washington subgroup also exhibits significant returns in most years. Returns to Issaquah Creek are typically lower than returns to the north-end tributaries. Lake spawners typically account for the smallest portion of the run, usually three orders of magnitude less than returns to the Cedar River (Hendry et al., 1996).

Stock Origin and Current Status

The Washington Department of Fisheries et al. (1993) identified four populations of anadromous sockeye salmon in Puget Sound: one population in the Baker River and three populations that occur in the Lake Washington watershed (Cedar River, Issaquah/Bear Creek, and Lake Washington beach spawners). Genetic research suggests that there are two subgroups in the Lake Washington watershed: a potentially native stock that spawns in Bear and Cottage Creeks at the north end of the system and a second stock derived from transplants of Baker River sockeye in the 1930s and 1940s that spawns in the Cedar River, Issaquah Creek, and on the beaches of Lake Washington (Hendry et al., 1996).

After building to relatively robust levels in the 1960s and 1970s, the Lake Washington Sockeye population has experienced a period of significant decline. The mean spawner return ratio during the last 11 brood years for which full return data is available is 0.79. This means that, on average, for each 100 fish that successfully spawns in the basin, only 79 fish have returned to spawn in the subsequent generation. Since record keeping began in 1967, the escapement goal for the system of 350,000 adult fish has been met or has been exceeded four times. Since the escapement goal was last achieved in 1988, the mean run size has been approximately 135,000 fish (WDFW, unpublished data). Washington Department of Fisheries and Western Washington Treaty Tribes (1993) classify the Lake Washington sockeye population as depressed in the Cedar River and elsewhere in the basin.

Sockeye harvest opportunities have recently declined in frequency. In 8 of the 22 years between 1967 and 1988, Tribal and sport fishers harvested substantial numbers of sockeye in Lake Washington. Since 1988, Tribal and sport harvests have been conducted in Lake Washington only in 1996 (WDFW, unpublished data). Although the 1996 return of approximately 450,000 adult fish indicates that the system has retained some potential to produce significant numbers of fish, the general trend in the sockeye population remains one of relatively steep decline.

Life History Overview

Sockeye salmon exhibit a typical salmon life history pattern that integrates anadromy (juveniles migrate to the ocean where they mature and return as adults to spawn in fresh water), homing (adults generally return to their natal streams to spawn), and semelparity (adults die after spawning once). Sockeye can also exhibit a resident life history that is similar to the typical pattern, but lacks the feature of anadromy (Burgner, 1991). These resident sockeye are called kokanee. Although small numbers of sockeye in the Lake Washington basin exhibit the resident life history pattern, including a population in Walsh Lake in the Cedar River Watershed, the vast majority of the population is anadromous. Unlike any of the other species of Pacific salmon, juvenile sockeye rear primarily in freshwater lakes.

Upstream Migration and Spawning

Adult sockeye salmon begin returning to the Lake Washington watershed through the Ballard Locks in late May with a peak migration in early July. By mid- to late August, essentially all fish have entered the lake (Warner, E., Muckleshoot Indian Tribe, 1998, personal communication). Once in the lake, the fish move into deep, cold areas below the thermocline. Adults will spend from 1 to 4 months in this region of the lake, where they undergo final sexual maturation (Parametrix, Inc., 1991). Most fish will move into tributary streams to spawn during the fall, but a relatively small proportion of the population will spawn in selected beach areas along the shores of Lake Washington, including the shoreline of Mercer Island and along the Lake Sammamish shoreline. The Cedar River supports the largest population of sockeye salmon in the Lake Washington basin with significant numbers of fish also spawning in the Bear Creek subbasin, and in North Creek, Swamp Creek, and Issaquah Creek. Although there have been exceptions in some years, approximately 90 percent of the returning fish typically spawn in the Cedar River (James M. Montgomery Inc., 1990; WDFW unpublished data).

Cedar River sockeye exhibit relatively protracted periods of spawning and incubation. Mature adults begin to enter the Cedar River in early September. Spawning activity begins to increase in mid-September and continues into January with a peak in mid- to late October (CES, 1995). Each female selects a site for spawning, digs a redd, and deposits an average of 3,200 eggs.

Incubation and Early Rearing

Alevins hatch from the eggs after 2 or 3 months and remain in the gravel for an additional 2-4 months, during which time they are sustained by their yolk sacs as they complete their development into free-swimming fry (Foerster, 1968; James M. Montgomery Inc., 1990).

Fry begin to emerge from the gravel in late January and continue through May, with a peak in late March and early April. Upon emergence, fry immediately begin migrating downstream. Most fry arrive at Lake Washington within 48 hours of emergence (Seiler and Kishimoto, 1996). Most juvenile sockeye reside in the lake for approximately 12-14 months, then undergo the process of smoltification as they migrate out of the lake into salt water via the Lake Washington Ship Canal and the Ballard Locks. These migrating smolts move out of the lake and into Puget Sound between April and June (James M. Montgomery Inc., 1990).

<u>Distribution in the Marine Environment</u>

After leaving Puget Sound, subadult sockeye move north along the continental shelf, into the Gulf of Alaska, and then migrate south into the open ocean. Once they reach maturity, the adult fish return to near-shore waters and migrate south along the coastline to Puget Sound and back to Lake Washington. The majority of Lake Washington sockeye return after 2 years at sea, however, a significant proportion from any give year class may return after 3 years at sea. Typically, a very small portion of the population (less than 1 percent) returns after only 1 year at sea (WDFW, unpublished data).

Habitat Characteristics and Key Factors Affecting Survival

A number of factors can potentially affect the survival of Lake Washington sockeye salmon at various stages of their life history, including habitat loss and degradation due to a variety of land and water management practices (King County, 1993); scour of incubating eggs and alevins during floods (Seiler and Kishimoto, 1997); predation by native and exotic fish in the Cedar River and Lake Washington (Beauchamp, 1993; Tabor and Chan, 1996); food supplies in the lake (Beauchamp, 1996); injury to smolts leaving the Lake via the Ballard Locks (Goetz et al., 1997); droughts; and unfavorable ocean conditions. As a result of the population's early run timing, harvest rates for Lake Washington sockeye are typically very low in the marine environment. Occasionally, early season harvests targeting up-river stocks of Fraser River Sockeye are permitted in north Puget Sound. This fishery must be carefully controlled to prevent unintentional overharvest of Lake Washington sockeye (Warner, E., Muckleshoot Indian Tribe, 1998, personal communication). Although sport and Tribal harvests in Lake Washington are typically well-controlled to ensure that adequate numbers of fish return to streams to spawn, Cedar River sockeye can be vulnerable to overharvest, as demonstrated during the 1996 season when insufficient numbers of fish returned to meet escapement goals after substantial sport and Tribal harvests in the lake.

Steelhead Trout

Steelhead trout (*Oncorhynchus mykiss)* are rainbow trout that display an anadromous life history pattern. Steelhead trout inhabit Pacific coast streams of North America and northern Asia. The original native range of North American steelhead extends southward from the northern side of the Alaska

Peninsula to northern Mexico. The present range is somewhat smaller because human activities have virtually eliminated steelhead populations south of San Francisco. In western Washington, steelhead are present in most Puget Sound drainages, coastal streams, and tributaries of the lower Columbia River.

Stock Origin and Current Status

The Lake Washington Basin is considered to have only 1 stock of native/wild steelhead trout. Historically, natural production has occurred in the Cedar River, Issaquah Creek, and north Lake Washington tributaries such as Bear Creek and the Sammamish River (WDF et al., 1993). The Lake Washington steelhead stock is considered to be depressed, and there is no longer significant natural production from any stream in the basin other than the Cedar River (Foley, S., WDFW, 1997, personal communication).

Hatchery steelhead have been planted extensively throughout the Lake Washington and Lake Sammamish basins with the first recorded plant occurring in 1915 (Ajawani, 1956). Between 1915 and 1954, over 1,073,000 steelhead fry were planted in the Lake Washington watershed (Ajawani, 1956). Additional hatchery plantings were made in the Cedar River and other Lake Washington and Lake Sammamish tributaries between 1954 and 1993 and the last steelhead planting to occur in the Cedar River was in 1993 (WDF et al., 1993). Like many early artificial production programs, the effectiveness of the early steelhead plantings was not rigorously monitored. Available data indicate that estimated levels of hatchery introgression among wild Cedar River steelhead is low as compared to other wild steelhead stocks in the region (Phelps et al., 1994). In 1997, WDFW, in cooperation with Trout Unlimited and the Muckleshoot Indian Tribe, started a wild broodstock program designed to incubate and rear Cedar River steelhead for out-planting in Issaquah and Bear Creeks, with the intent of re-establishing the species in these streams.

On February 16, 1994, a comprehensive petition to list west coast steelhead was submitted by Oregon Natural Resources Council and 15 co-petitioners. In response to this petition, NMFS assessed the best available scientific and commercial data, including technical information from Pacific Salmon Biological Technical Committees and interested parties in Washington, Oregon, Idaho and California. NMFS also established a Biological Review Team, composed of staff from NMFS's Northwest and Southwest Fisheries Science Centers and Southwest Regional Office, as well as a representative of the National Biological Service, which conducted a coast-wide status review for west coast steelhead (Busby et al., 1996).

Based on the results of the Biological Review Team's report, and after considering other information and existing conservation measures, NMFS published a proposed listing determination that identified 15 Ecologically Significant Units (ESUs) of steelhead in the states of Washington, Oregon, Idaho and California. Ten of these ESUs were proposed for listing as threatened or endangered, four were found not warranted for listing, and one was identified as a candidate for listing. The Lake Washington steelhead population is included in the Puget Sound ESU, which did not warrant listing.

As previously mentioned, the status Lake Washington basin steelhead, of which the Cedar River run is the largest component, was deemed depressed in the WDF Salmon and Steelhead Stock Inventory (1993), a report developed prior to the lowest recorded return (70 fish) in 1994. Between 1983 and 1997, escapement estimates for the Lake Washington basin ranged from 2,575 fish in 1983 to 70 fish in 1994 (all of which were in the Cedar River). The average escapement for this time period was 800 fish. Very low returns in the early 1990s resulted in the closing of all recreational fisheries in the Cedar River until steelhead numbers return to healthy levels. Since the record low return in 1994, steelhead escapement estimates have increased each year from 126 fish in 1995 to 616 fish in 1997.

Life History Overview

Steelhead are anadromous fish that home to their natal rivers to spawn. They exhibit an iteroparous life history (do not die after spawning) unlike the semelparous Pacific salmons. Steelhead populations are typically divided into two seasonal races of fish that are primarily defined by the timing of adult returns to spawning streams and by the state of sexual maturity upon entry into fresh water (Neave, 1944; Shapovalov and Taft, 1954; Bali, 1959; Withler, 1966; Smith, 1968). Summer steelhead is the term given to fish that return to fresh water between May and October, and winter steelhead is the term given to fish that return to fresh water between November and April (Withler, 1966; Smith, 1968).

Cedar River steelhead are a coastal population of winter race fish. Historically, adult steelhead enter Lake Washington through the Ballard Locks between December and early May (WDF et al. 1993). They spawn primarily in the mainstem from March through early June (Burton and Little, 1997), although there are historic records of steelhead spawning in Cedar River tributaries such as Rock Creek (below Landsburg Diversion Dam).

<u>Spawning</u>

Steelhead spawning behavior is similar to that of other salmonids. The female locates an area of suitable substrate where she digs a depression in the gravel forming a nest. Males compete to court the female and fertilize her eggs as they are extruded.

Before steelhead undertake their first spawning migration they are termed maiden fish. If these maiden fish survive their first spawning and manage to return to the sea they are referred to as kelts. Studies in Alaska and Canada suggest that approximately 80 percent of repeat spawners are females (Hooton et al., 1987; Didier, 1990).

Steelhead trout take advantage of a wide range of spawning habitats including large mainstem habitats and small perennial streams such as Rock Creek below Landsburg Diversion Dam. Steelhead usually spawn in medium to high gradient sections of streams at the tails of pools or at the heads of riffles, where hydrologic conditions maintain adequate intergravel flows that provide an oxygenated environment for egg incubation (Greeley, 1932; Orcutt, et al. 1968).

Incubation and Rearing

Steelhead typically hatch between 4 and 8 weeks after fertilization and the larval fish (alevins) remain in the redd for an additional 3 to 5 weeks, absorbing nutrients from a yolk sac connected to their abdomen. Emergence studies occurring in the Cedar River in 1996 and 1997 indicate that fry emergence for an individual redd begins approximately 54 days after fertilization and is complete approximately 63 days after fertilization (Burton and Little, 1997). The emergence period for Cedar River steelhead lasts from late May to early August with peak emergence occurring in mid- to late July (Burton and Little, 1997).

Steelhead typically reside in the stream for 2-3 years, although a small number of fish may out-migrate after 1 year.

Cedar River steelhead rear in the mainstem and tributaries below Landsburg Diversion Dam. The majority of Cedar River fish are believed to out-migrate as smolts after 2 years of freshwater residence. Size, not age, is the main determinant in smolt out-migration. Fish from less productive systems take longer to reach smolt size and, therefore, are older when they begin to migrate to the ocean. Cedar River steelhead smolts tend to attain large sizes compared to other local and regional stocks (Foley, S., WDFW, 1997, personal communication).

Distribution in the Marine Environment

Generally, steelhead outmigration from fresh water occurs in the spring between mid-March and early June. The peak of the smolt migration usually coincides with peak spring runoff in mid-April to mid-May. The majority of steelhead smolts appear to migrate directly to the open ocean and do not spend significant amounts of time in the estuarine or coastal environments around their birth stream (Burgner et al., 1992). Timing of Cedar River steelhead smolt out-migration is not well understood, although there are ongoing studies being conducted at the Ballard Locks.

After spending 2-3 years in the ocean, the majority of steelhead become mature and leave their feeding grounds to migrate back to their birth stream. Very few fish return after only 1 year in the marine environment, and some fish remain in the ocean for up to 6 years.

Habitat Characteristics and Key Factors Affecting Survival

Steelhead trout currently spawn and rear in the 21.8 miles of mainstem river habitat downstream of the Landsburg Diversion Dam and can be expected to colonize the habitat above Landsburg Dam if fish passage facilities are provided. Access to the upstream habitat would contribute significant benefits to the population if other factors outside the watershed do not adversely affect their survival. Although the habitat in the Cedar River below Landsburg Dam has been modified by channel confinement structures, increased impervious surfaces, commercial and agricultural development and a general lack of riparian forest cover and large woody debris, it is still considered to provide the best steelhead habitat in the basin (Foley, S., WDFW, 1997, personal communication).

Non-Anadromous Fish Species of Concern

There are three main geographic areas within the Cedar River Watershed, each with a unique set of fish assemblages (See Map 1 and Map 7). The upper municipal watershed above the Masonry Dam is primarily high relief, mountainous land. The upper municipal watershed includes resident populations of rainbow trout, as well as adfluvial forms of bull trout, rainbow trout, and pygmy whitefish that migrate from Chester Morse Lake to spawn in tributary rivers and streams.

To the south is the Taylor Creek drainage, composed of lower hills with lower relief than the upper municipal watershed. Fish resources within Taylor Creek are comprised of sympatric populations of nonanadromous rainbow trout and coastal cutthroat trout. An impassable waterfall barrier near the mouth of Taylor Creek precludes use by anadromous salmonids.

To the west of the upper municipal watershed and north of Taylor Creek drainage is a relatively flat lowland area bordered by steeper topography and including smaller tributaries such as Williams, Rock, Steele Creek, and the Walsh Lake Ditch. Historically, anadromous fish accessed the Cedar River up to Cedar Falls and presumably other accessible tributaries in this area. Currently, only resident populations of cutthroat trout and rainbow trout use the streams within this area. Cutthroat trout dominate the small basins that flow into the Cedar River from the north, while rainbow trout dominate the mainstem Cedar River. Some hybridization between the two species has likely occurred in the Taylor Creek drainage and the Cedar River and associated tributaries below Cedar Falls.

The far northwestern portion of the study area includes the Walsh Lake Basin and Carey Creek. The Walsh Lake Basin and Carey Creek are the only streams within the Cedar River Watershed currently accessed by anadromous fish. Walsh Lake provides habitat for self sustaining populations of both cold- and warm-water species. Coho salmon were observed spawning in the Walsh Lake Diversion in 1997 (SPU, 1998a; HCP Technical Appendix 23). The water from the lake has been diverted since the early 1930s and rejoins the Cedar River downstream of the Landsburg Diversion. In 1997, Kokanee, or landlocked sockeye were documented for the first time to occur in Walsh Lake.

Approximately 1 mile of Carey Creek is situated in the far northwest corner of the City landholdings. It flows to the north to join Issaquah Creek rather than the Cedar River.

Bull Trout

Bull trout are known to inhabit Chester Morse Lake, Masonry Pool, and accessible portions of major tributaries upstream of the lake (Map 7). The population of Chester Morse Lake bull trout was conservatively estimated to be approximately 3,100 fish in 1995 (R2 Resource Consultants, in preparation). This figure is most likely an underestimate due to the sampling techniques employed for the study. The abundance of bull trout in the Masonry Pool is much less, estimated at approximately 150 fish. In the Cedar River and Rex River, estimated density of rearing bull trout density ranged from 69 to 543 fish per acre.

Bull Trout

No substantive evidence to date indicates that either a self sustaining population of bull trout or any significant number of individuals exists in the approximate 14 miles of the mainstem Cedar River, or its tributaries, between the Masonry Dam and the Landsburg Diversion Dam. Although passage over the Masonry Dam, and subsequent downstream movement, of a limited number of bull trout is expected to occasionally occur during seasonal spillway releases of water from the Masonry Pool, it apparently has not been sufficient to support establishment of bull trout populations under the ecological conditions existing in downstream reaches. Only recently has an observation been documented from this reach, an incidental sighting of a single adult bull trout near the powerhouse at Cedar Falls during September, 1997 (Binkley, K., Seattle City Light, Personal communication, 1997).

Until recently, only limited sampling of the Cedar River and its tributaries between the Masonry Dam and the Landsburg Diversion Dam had been conducted. Casne (1975) reported that rainbow trout were predominant in the river, and did not report capturing bull trout. Similarly, no bull trout have been documented by Water Department, Seattle Public Utilities, or other state agency personnel during subsequent, periodic sampling efforts.

Most recently (1994), City personnel, with Taylor Associates, conducted systematic snorkel surveys of four, 1-mile reaches and two, 100-meter reaches of the 12.5-mile section of the mainstem Cedar River between Landsburg Diversion Dam and the natural passage barrier approximately 0.75 mile upstream of Cedar Falls. All sample reaches were sampled during daylight hours and two, 1-mile reaches were sampled at night.   Of the total 5,250 salmonids observed, none were identified as bull trout.

Stock Origin and Current Status

Bull trout are native to the Cedar River Watershed. Prior to 1978 there was no designated species separation between bull trout and Dolly Varden. Because these two species may overlap in range, particularly in Puget Sound, detailed physical analysis (meristics) are required to determine which of the two species are present. A detailed meristics analysis conducted on 1995 indicated that Cedar River Watershed fish were bull trout, not Dolly Varden (R2 Resource Consultants, in preparation).

Bull trout are a western North American char that were originally classified as a candidate species for federal listing under the ESA in 1994 (FR Vol. 89, No. 111). The FWS proposed listing the Columbia River Basin populations as threatened (FR Vol. 62, No. 114, June 13, 1997), and published the final rule listing those populations as threatened on June 10, 1998 (FR Vol. 63, No. 111, pp. 31647031674). Recently, Coastal-Puget Sound, Jarbridge River, and St. Mary-Betty River population segments of bull trout were proposed to be listed as threatened species (FR Vol. 63, No. 111, pp. 31693 to 31710). The species is declining in numbers throughout its range, especially along its southern limits (McPhail and Baxter, 1996). Overfishing, human-made migration barriers, increased siltation, changes in temperature and flow regimes, and competition and hybridization with introduced salmonids are the predominant causes of declining populations (McPhail and Baxter, 1996).

Bull trout are regarded as a priority species by the Washington Department of Wildlife. Priority species are those fish and wildlife that are of concern due to their population status and sensitivity to habitat alteration. It has no state status as a listed or candidate species, although it is considered to be vulnerable to significant population declines (WDFW, 1996). In a report assessing the status of bull trout/Dolly Varden in Washington State, WDFW found that of the 80 identified stocks placed into five categories of rating (healthy, depressed, critical, unknown, or extinct), 72.5 percent were unknown, and 17.5 percent were categorized as healthy (WDFW, 1997a). The Chester Morse Lake stock of bull trout is classified as unknown. However, the assessment states "there are no data suggesting a chronically low condition, or short-term severe decline" in the population, and the stock status "may be healthy" (WDFW, 1998). Because of the concern about the future of this species, the Washington Wildlife Commission severely restricted harvest of bull trout throughout the state. Since 1908, the Cedar River Watershed has been closed to public access, and the bull trout population has not been fished or harvested.

Life History Strategies

Several types of life history strategies are employed by bull trout in freshwater systems in western Washington streams, including adfluvial (migrate between lake and streams), fluvial (migrate within river system), and resident forms (nonmigratory). Three freshwater forms of bull trout could potentially utilize streams in the Cedar River Watershed. Analysis of data collected to date indicates that bull trout in the upper Cedar River Watershed have an adfluvial life cycle and inhabit the Masonry Pool and Chester Morse Lake (R2 Resource Consultants, in preparation; Wyman, 1975).

Adfluvial bull trout rear as small juveniles in the tributaries, migrate to the lakes where most growth occurs, then return to the tributaries as adults to spawn. After spawning, adult bull trout return to Chester Morse Lake. Bull trout become mature at approximately 5 years of age in Chester Morse Lake and have a potential lifespan exceeding 12 years of age (R2 Resource Consultants, in preparation). No fluvial or resident forms have been confirmed to inhabit the basin, and it is suspected that all of the larger spawning bull trout mature in Chester Morse Lake. Using results from age and growth sampling, R2 Resource Consultants (in preparation) concluded that the lack of older fish during nonspawning periods in the streams confirms the primarily adfluvial characteristics of this stock. In addition, no bull trout have ever been confirmed to inhabit stream reaches upstream of migration barriers that prohibit upstream movement of fish from the Chester Morse Lake (SPU staff, Personal communication).

Bull trout spawning is strongly influenced by stream temperature and stream flows. Most bull trout reproduction occurs during the months of October and November as stream temperatures decline. Spawning surveys conducted on the Wenatchee National Forest over the past eight years confirm that redd construction generally begins as temperatures decline below 11°C to 9°C

(Brown, 1992). Spawning sites are commonly found in association with groundwater upwelling in other watersheds (Goetz, 1989; McPhail and Baxter, 1996), although no temperature differential was found at redd sites in the Cedar River Watershed (R2 Resource Consultants, in preparation). The incubation period for bull trout embryo occurs during the winter months, and fry emergence commences in late March and peaks in April. The long overwinter incubation period (up to 6 months, depending upon water temperature) leaves them vulnerable to hydraulic changes and sediment inputs.

Bull trout spawn in the Cedar and Rex Rivers, as well as in some of the smaller tributaries to Chester Morse Lake (Map 7). Some of the spawning areas used in the Cedar and Rex Rivers occur in regions that can be flooded during high water levels in Chester Morse Lake, especially in the Rex River. The extent to which bull trout spawning habitat is inundated varies among years depending on weather and fluctuations in the reservoir level (see section on Current Reservoir Operational Levels in this chapter).

In streams, bull trout are primarily bottom dwellers, occupying positions in contact with, and often within, the substrate. Newly emerged fry are often found in shallow, slow backwater side channels or alcove pools, often in association with woody debris and fine substrates (Goetz, 1991). Studies from across western North America, including research conducted in the Cedar River, exemplify a range of habitats utilized by rearing bull trout, but they are commonly associated with clean large cobble and boulder substrate, woody debris, and deep scour and plunge pools (Shepard et al., 1984; Fraley and Shepard, 1989; Heifetz et al., 1986; Goetz, 1991; R2 Resource Consultants, in preparation). As bull trout grow, they typically are found in deeper and faster water, often in pools with shelter provided by boulder substrate or wood. The highest densities of bull trout in the Cedar and Rex Rivers were found in areas having both abundant woody debris and hydraulic complexity (R2 Resource Consultants, in preparation).

Adfluvial bull trout in the Watershed remain in the tributaries from 1 to 3 years, after which they migrate to Chester Morse Lake (R2 Resource Consultants, in preparation). Analysis of bull trout length data suggests that most fish migrate to Chester Morse Lake within their first year of life (R2 Resource Consultants, in preparation). When bull trout attain sufficient size, their diet includes small fish. Adfluvial bull trout in the Cedar River Watershed prey on pygmy whitefish and sculpin upon entering the lake environment. With a better supply of larger food items, growth increases accordingly. In watersheds throughout western North America, the adfluvial form of bull trout typically attains a much larger size than the resident stream form, reaching up to 30 inches and 10 pounds at maturity. Fish up to 23 inches in length have been captured in Chester Morse Lake.

Rainbow Trout

Rainbow trout are widely distributed in the Cedar River Watershed and are present in Chester Morse Lake, Masonry Pool, and selected major tributaries of Chester Morse Lake, including the Cedar and Rex Rivers (Map 7). The distribution of this species in many smaller tributaries of the Cedar River Watershed and the Taylor Creek drainage is still uncertain.

Stock Origin and Current Status

In addition to the wild population of winter steelhead found below Landsburg Diversion Dam, there are also two populations of resident rainbow trout above the diversion. The first population occurs between Landsburg and Cedar Falls, the historic natural barrier to anadromous fishes. The second population occurs in Chester Morse Lake and its tributaries. Genetic analysis of these populations suggests that rainbow trout in Chester Morse Lake were derived from a hatchery planting, however not necessarily from one of the strains currently maintained at the WDFW hatcheries. In contrast, the rainbow trout population between Landsburg and Cedar Falls are more similar to Cedar River and Puget Sound steelhead than to Chester Morse rainbow trout. However, the rainbow trout population above Landsburg Dam also contains alleles from hatchery rainbow trout. Because these alleles are spread throughout the population, the hypothesis that there has been interbreeding between hatchery-origin and wild fish in this reach is supported.

Because of the introgression with nonnative, hatchery-origin rainbow trout, neither of the resident rainbow populations in the municipal watershed are considered suitable for artificial supplementation of steelhead in the Lake Washington Basin (Phelps, S., WDFW, 1998, personal communication).

Rainbow trout are one of the more common Washington native fish species found in the Columbia River drainage, coastal streams, and Puget Sound streams. While some stocks of Washington State steelhead, the anadromous form of rainbow trout, have been federally listed under the ESA, no Washington State resident rainbow trout stock is federally listed or proposed for listing. Washington State has designated rainbow trout as a game species and it is not listed as endangered or proposed as a candidate stock (WDFW, 1996). The rainbow trout in the upper Cedar River Watershed is of special management concern because it is one of only two adfluvial populations in Washington State that are sustained solely by natural spawning without supplementation (Wydoski and Whitney, 1979), and it is the only natural spawning population that is not being affected by harvest.

Life History Strategies

Rainbow trout typically spawn from February to June in Washington. Spawn timing varies with elevation and water temperature. Peak fry emergence time occurs after a 40- to 70-day incubation period depending upon water temperatures, and spawning and incubation activity is over by late summer. The stream life history of the resident rainbow is similar to the juvenile steelhead. As fish grow, they move to faster and deeper waters, with adequate cover formed by depth, surface turbulence, substrate, or woody debris. During summer months they select optimal feeding stations where they capture drifting invertebrates.

Both resident and adfluvial forms of rainbow trout are present in the Watershed above Masonry Dam. Adfluvial fish may rear in the stream for up to 2 years or more (Wyman, 1975; R2 Resource Consultants, in preparation), then return to a lake for further rearing, thus attaining much greater size than the stream resident populations. The smaller size by age in tributaries is common because of lower food supply and greater energy demands in the streams. Rainbow trout that migrate to Chester Morse Lake reach lengths of 20 inches and live up to 7 years.

Results of fish capture surveys conducted in Chester Morse Lake indicate that rainbow trout were concentrated within the littoral zone (defined as the area present along the lake periphery extending vertically to a depth of 50 feet) and river delta areas of the lake. Portions of the littoral areas of Chester Morse Lake offer abundant habitat cover for rainbow trout, including high densities of stumps, thick growths of aquatic plants, and logs.

The adfluvial rainbow trout spawn primarily in the mainstem of the Rex and Cedar Rivers and a number of the lower gradient, accessible tributaries that enter the lake (Map 7) during April and May. Spawning sites typically were found near channel margins and often associated with deep scour pools in conjunction with large woody debris (R2 Resource Consultants, in preparation). As gradient increased up the river valleys, and cobble and boulders became more abundant, density of observed redds decreased. During the study period, rainbow trout did not spawn in the inundated lower reaches of the Rex and Cedar Rivers.

Cutthroat Trout

Cutthroat trout are a common Washington native fish species found in coastal and Puget Sound streams. Cutthroat trout are abundant in streams draining into Lake Washington and support a significant sport fishery (Bob Pfeifer, WDFW, 1998, Personal communication); however, the Cedar River is closed to sportfishing (WDFW, 1997c). Cutthroat trout are also an important component of the Lake Washington ecosystem and provide an important ecological niche as a top predator.

Stock Origin and Current Status

Cutthroat trout (*O. clarki*) exhibit considerable diversity in geographic range, life history, and ecology and has been divided into 13 subspecies. The coastal cutthroat trout (*O. clarki clarki*) subspecies that is found in the Cedar River Watershed is native to Puget Sound streams and the Cedar River.

The population in the Cedar River Watershed is likely a native stock, although coastal cutthroat were stocked in numerous Washington streams as early as 1895 (Crawford, 1979). Cutthroat trout have been stocked in the Cedar River to some extent beginning in 1915 (HRC, 1995). Stocking records indicate that cutthroat trout were stocked in the Cedar River Watershed in 1920, but there is no indication of planting location (Department of Fisheries and Game, Thirtieth and Thirty-First Annual Reports).

Coastal cutthroat trout exhibit a variety of population forms, including anadromous, adfluvial, and stream resident. Prior to the historic diversion of the Cedar River into Lake Washington and construction of the Landsburg Dam, anadromous populations of coastal cutthroat trout are suspected to have migrated into the Cedar River Watershed. Adult sea-run cutthroat trout spawners tend to utilize the extreme upper reaches of small streams, ascending above the areas utilized by other anadromous salmonids. For this reason, it is likely that anadromous cutthroat at one time ascended into stream basins to the north of the Cedar River mainstem downstream of Cedar Falls (e.g., Williams, Rock, Walsh, and Steele stream basins). These basins are now dominated by stream resident cutthroat trout, suggesting that accessible reaches may have been used by sea-run cutthroat trout prior to river alterations previously described.

It is currently not known what proportion of the Cedar River cutthroat trout population downstream of the Landsburg Diversion are anadromous, fluvial, or adfluvial. There are no records indicating that sea-run cutthroat trout use the fish ladder at the Ballard Locks. Large cutthroat trout have been observed in the river, suggesting some fish have an anadromous or adfluvial life history. Sea-run cutthroat trout use of the streams that flow into Lake Washington is poorly understood.

Stream resident cutthroat are widely distributed in the Taylor Creek drainage and tributaries to the Cedar River downstream of Cedar Falls (Map 7). No cutthroat trout have been observed within the Masonry Pool or Chester Morse Lake and its tributary streams.

Life History Strategies

To date, little information is available on the abundance, distribution, and life history strategies of cutthroat trout in the Cedar River Watershed. Only stream resident forms of cutthroat trout now exist in the Cedar River Watershed above Landsburg Dam. Coastal cutthroat trout throughout western Washington are spring spawners; spawning commences as early as February to April, depending largely on elevation and water temperatures. Rearing habitat use by coastal cutthroat is generally similar to rainbow trout and steelhead. However, coastal cutthroat trout coevolved with steelhead and resident rainbow and have coexisted by partitioning habitat. Because of their lower swimming abilities than the rainbow, cutthroat are less apt to occupy swift water (Bisson et al., 1988). Cutthroat are commonly associated with areas of abundant instream cover, such as woody debris and overhanging vegetation that can provide water velocity breaks. Rainbow trout and steelhead usually predominate in the lower reaches of jointly occupied watersheds, while cutthroat trout will be found in small streams in the upper reaches.

Pygmy Whitefish

Pygmy whitefish are the most abundant native salmonid species in Chester Morse Lake and are present, though in low abundance, in Masonry Pool (R2 Resource Consultants, in preparation). This species is an important prey item of bull trout in Chester Morse Lake.

Stock Origin and Current Status

Pygmy whitefish are primarily found in relic populations in western North America including British Columbia, Washington, Montana, and Alaska. The life history and ecology are not well known, as very few studies of this species have been conducted in the past and the population status of this species is largely unknown in Washington. Stocks are declining in eastern Washington systems, primarily as a result of introduced nonnative species (WDFW unpublished data as reported by R2 Resource Consultants, in preparation). Pygmy whitefish is listed as a Washington State candidate species because of its clustering in a few locations, lack of connections between isolated populations, declining numbers, and the potential for continued significant population losses (WDFW, 1996). It is currently not a federally listed or candidate species.

Chester Morse Lake contains one of only nine known native pygmy whitefish populations in Washington (M. Hallock, WDFW, 1998, Personal communication). The restriction of human activity and harvest, lack of successful nonnative fish introduction, and preservation of water quality have all contributed to producing one of the most abundant pygmy whitefish populations in Washington State (City of Seattle, 1998).

Life History Strategies

Pygmy whitefish inhabit lakes and cold streams throughout its range. No pygmy whitefish were observed in any stream locations sampled during intensive electrofishing and snorkeling in the Cedar River and its tributaries (R2 Resource Consultants, in preparation) during spring through autumn periods. Pygmy whitefish are thought to spawn from December to January and have been observed to spawn in riffle areas of streams and along lake shores (Wydoski and Whitney, 1979).

Little is known about pygmy whitefish spawning behavior, incubation, and early life history in the Cedar River Watershed. It is presumed pygmy whitefish spawn by broadcasting their eggs on clean gravel or rocky areas (Wydoski and Whitney, 1979). In contrast to the trout and salmon, no digging occurs. However, whitefish eggs are also relatively small compared to trout eggs and require a substantially shorter incubation period. Large aggregations of sexually mature fish have been observed in the Cedar River, Rex River, and Boulder Creek during early December (Map 7). As many as 1,000 fish were observed in the Cedar River above Camp 18 during December 1996 and December 1997 (SPU, unpublished data). Searches in other accessible tributary streams or along selected beach areas during the same time period revealed no pygmy whitefish. Detailed studies to investigate the occurrence of lake spawning in Chester Morse Lake or Masonry Pool have not been conducted.

Results of hydroacoustics and gill netting surveys conducted in the Chester Morse Lake indicate that pygmy whitefish are widely distributed in the lake with the highest densities observed in deep areas (depths of 90 feet or greater) near the lake bottom (R2 Resource Consultants, in preparation; EVS Consultants, 1984; Parametrix and Biosonics, 1981). Throughout its range, the species is typically considered a deep-water species and is usually found in water deeper than 20 feet (Scott and Crossman, 1973). Analysis of hydroacoustic data from Chester Morse Lake and Masonry Pool suggests that pygmy whitefish maintain position upon or near the bottom of the lake during periods of light to avoid bull trout, their only predator in the lake (R2 Resource Consultants, in preparation). Some pygmy whitefish appear to move into pelagic and littoral areas of the lake at night to feed. The diet of pygmy whitefish is typically composed of bottom organisms (Wydoski and Whitney, 1979), including macroinverterbrates of the Chironomidae and Ceratopogonidae family and various small clams. Feeding habits of pygmy whitefish in Chester Morse Lake are fairly consistent among seasons, probably because of their reliance on lake bottom benthic organisms.

Other Non-Anadromous Fish

Numerous other species of freshwater fish also inhabit the Cedar River and tributaries for part, or all of their lives (Map 7). Within the portion of the Cedar River Watershed owned and operated by the City of Seattle, other resident freshwater fish sampled in the Walsh Lake Basin include: western brook lamprey (*Lampetra richardsoni*), speckled dace (*Rhinichthys osculus*), redside shiner (*Richardsonius baleatus*), northern squawfish (*Ptychochelius oregonesis*), and sculpins (*Cottus* spp.) (SPU, HCP; Technical Appendix 23). Largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*) were planted in Walsh Lake a number of years ago, and now naturally propagate.

Kokanee (*O. nerka*) were recently discovered in Walsh Lake; the origin of this stock remains unknown (SPU, 1998; HCP Technical Appendix 23). Kokanee are landlocked sockeye salmon that sustain their population without migration to the ocean. Sexually mature adults were observed in lake netting sampling, and subsequent spawning investigations revealed kokanee spawning activity in Webster Creek, a tributary to Walsh Lake. Sampling of Walsh Lake conducted in the late 1970s revealed no kokanee (Congleton et al., 1977)

Golden trout (*Salmo aguabonita*) were stocked in Findley Lake in the past, but this supplementation has long been terminated. There is no evidence that the lake any longer supports the species (D. Paige, SPU, Personal communication).

A permit was also granted in 1920 to stock 613,500 eastern brook trout (*Salvelinus fontinalus*) in the Cedar River, but it is unclear if the stocking of such a magnitude was completed (HRC, 1995). Planting records do indicate that 8,000 eastern brook trout were planted into Walsh Lake in 1920. Nevertheless, no brook trout are known to reside in the Cedar River or Walsh Lake at this time.

Other resident freshwater fish reported to inhabit the Cedar River downstream of the Landsburg Diversion include (City of Seattle, 1998; King County Department of Public Works, 1993) mountain whitefish (*Prosopium williamsoni*), Pacific lamprey (*Entosphenus tridentatus*), river lamprey (*Lampetra ayresi*), and three-spine stickleback (*Gasterosteus aculeatus*). Several fish spend most of their life span in Lake Washington but utilize the Cedar River for feeding or spawning during a portion of their lives. These include (King County Department of Public Works, 1993) longfin smelt (*Spirinchus thaleichthys*), peamouth chub (*Mylocheilus caurinus*), and largescale suckers (*Catostomus macrocheilus*).

3.4.2 Fisheries Habitat

The mainstem of the Cedar River and its tributary network provide abundant and varied salmonid habitat. Over 90 miles of streams supporting fish are recognized in the Cedar River Watershed above the Landsburg Diversion Dam (Map 7). An additional 21.8 miles of the mainstem Cedar River flows below the Landsburg Diversion Dam prior to entering Lake Washington. The fish habitat that would be affected by the Proposed HCP Alternative actions are divided into two discrete areas for planning purposes, that above the Landsburg Diversion Dam and that below. Because mitigation and restoration alternatives for the two areas are distinctly different, fish habitat will be described separately for each. The area referred to as the Municipal Watershed totals 90,500 acres of forested land owned by the City of Seattle and managed by Seattle Public Utilities. The Watershed includes the mainstem river and tributary basins upstream of the Landsburg Diversion Dam (Map 2). The fisheries resources of Lake Washington are also addressed, as they directly influence the salmonid resources within the planning area. Small tributary basins downstream of the Landsburg Diversion Dam would not be affected by the actions or mitigation associated with the proposed HCP and are not further discussed.

Fisheries Habitat Upstream of the Landsburg Diversion

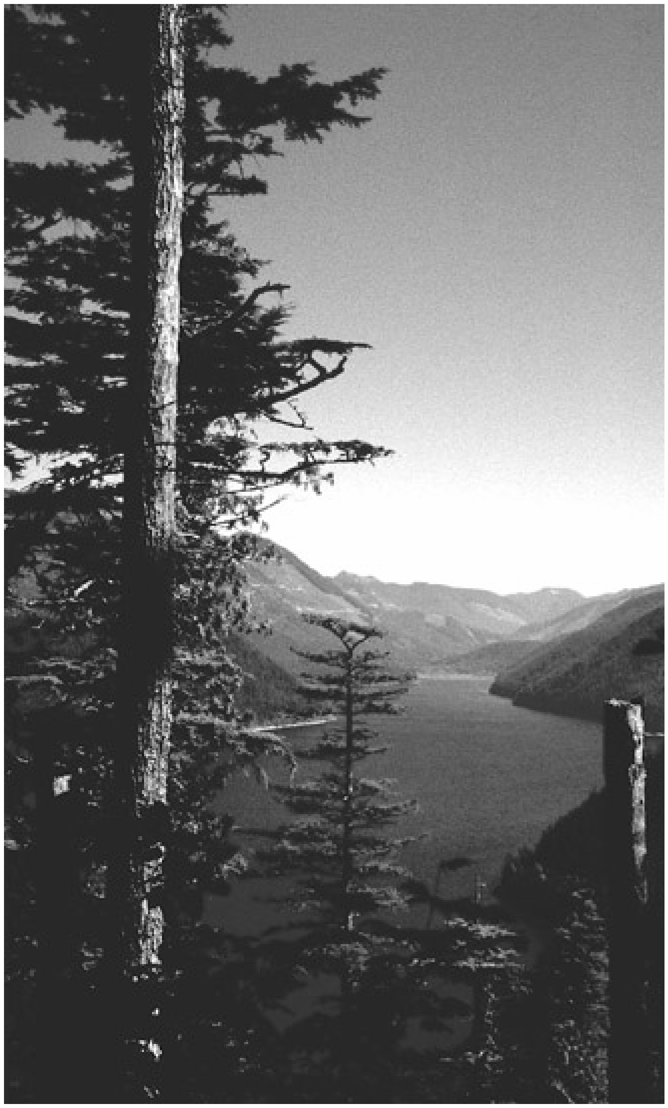
Cedar River between the Landsburg Diversion to Masonry Dam

The Municipal Watershed above Landsburg Diversion contains 14.2 miles of mainstem river provided by the lower Cedar River. Immediately below the Masonry Dam downstream to Lower Cedar Falls, the Cedar River flows at a relatively high gradient. Lower Cedar Falls is an impassable blockage to upstream migration. Below Lower Cedar Falls to Landsburg Diversion, the mainstem Cedar River has incised down through glacial deposits, resulting in a narrow floodplain contained within terrace walls. The channel is moderately confined by narrow, discontinuous alluvial terraces. Potential spawning habitats are locally abundant, especially below the confluence with Taylor Creek, Chester Morse Lake, and Masonry Pool.

Chester Morse Lake occupies a natural lake basin that was elevated and expanded in 1917 by construction of the Masonry Dam The Masonry Pool, immediately west of Chester Morse Lake, serves as an additional impoundment (Map 2). Water released from the Masonry Dam, located at the west end of the Masonry Pool, drives two turbine generators at Seattle City Light's powerhouse at Cedar Falls before being returned to the Cedar River. In addition to the stored water readily available through gravity flow, Chester Morse Lake contains significant amounts of high quality water held below the level of its natural outlet.

Chester Morse Lake generally has a steep shoreline. Much of the lake is approximately 115 feet deep. The addition of a dam at the lake outlet, known as the overflow dike, has allowed for annual water level fluctuations that average about 23 feet. A new dam was placed at the lake outlet in 1988, allowing the lake to remain on average about 2 to 5 feet higher in elevation than in earlier years. Water level changes are highly variable due to annual variability in water supply. Under current operation, lowest water levels typically occur in early fall with increased levels resulting from commencement of fall rains. Highest average water lake levels typically occur in mid-spring resulting from spring snow melt. The timing, duration, and depth of water level fluctuations can affect spawning success of adfluvial populations of bull trout and rainbow trout. These fluctuations also affect the availability of shoreline littoral habitats that rainbow trout use almost exclusively.

The Masonry Pool is about 160 acres in size with an annual drawdown between 30 and 50 feet. Its shoreline is less steep than Chester Morse Lake, and the maximum depth is about 60 feet. Because of the gradual shoreline slope, much of this lake bottom area is dewatered annually.



Chester Morse Lake

Current Reservoir Operational Effects

The SPU's current operation of Chester Morse Lake and Masonry Pool as a water storage/municipal water supply results in seasonal changes in lake level. Current reservoir operation limits range from 1,563 feet above sea level at full pool to a minimum drawdown of 1,532 feet. Under emergency conditions, it can be lowered to 1,502 feet using existing pumping systems (See Section 3.2).

Water levels are maintained at approximately 1,550 feet to provide for flood protection from November to February when water supply from the upper Cedar River Watershed exceeds demands. In the spring, the level of Chester Morse Lake increases with spring runoff and the need to maximize storage for the approaching summer (high water demand) period. Typically, between June and October, the water level drops due to decreased inflow, increased water demand, and the need to provide instream flows for downstream aquatic resources.

Total reservoir area within Chester Morse Lake decreases significantly coincident with drawdown during fall/winter months. The net change in reservoir area between full pool (1,563 feet) and current normal operational drawdown limit (1,532 feet) equates to a reduction in reservoir surface area of approximately 600 acres. Likewise, total reservoir area in Masonry Pool is also decreased significantly with fall/winter drawdown. The change in reservoir area between “full pool” (1,563 feet water surface elevation) and the current operational drawdown limit (1,510 feet) nearly dewaters most of the lake bottom.

The potential impacts associated with the current operation of Chester Morse Lake include inundation of tributary habitats used by spring and fall spawning fish, possible creation of physical obstructions to the upstream migration of spawning fish, and seasonal changes in the quantity and availability of specific lake habitats. Each of these impacts related to the current operation of Chester Morse Lake is discussed below.

Littoral Habitat and Food Availability

The lake littoral habitat is considered of primary importance to nearshore rearing fish species and is typically the region of highest benthic (or bottom-dwelling) organism production, an important food source for all lake fish species. The littoral region generally corresponds to the region where most of the growth of attached algae occurs. Delineation of the littoral zone and quantification of littoral habitat within Chester Morse Lake was accomplished by using euphotic zone measurements (the region of the water column in which plants can photosynthesize, which corresponds roughly to the depth of light transmission) and bathymetric analysis to determine areas where significant shore and bottom influences occurred in conjunction with photosynthetic activity (R2 Resource Consultants, in preparation). The littoral zone within Chester Morse Lake was defined as the area present along the lake periphery extending vertically to a depth of 50 feet. At the current full pool level of 1,563 feet, the littoral region of Chester Morse Lake is approximately 750 acres. As water level decreases to the current operation level limit of 1,532 feet, a 61 percent reduction (750 acres down to 290 acres) occurs in littoral habitat. It should be noted that the reservoir is rarely (i.e. 1 in 50 years) drawn down to the l,532 feet level.

As for the salmonids using the lake environment, rainbow trout rely more heavily on nearshore terrestrial and littoral benthic resources and are likely most affected by the changes in available littoral habitats. Bull trout and pygmy whitefish are presumed to be more dependent on resources from non-littoral areas and thought to be less affected.

Migration Barriers

The potential for formation of upstream migration barriers of fall spawning bull trout may exist as a result of the current operations of Chester Morse Lake. Entrance and access to tributary habitats by fall spawning fish species may be restricted or precluded due to the existing channel/reservoir topography where the Cedar and Rex River deltas meet the main body of Chester Morse Lake. Detailed bathymetry conducted at the downstream edge of the Cedar and Rex River deltas determined that the slope in the steep areas of the Rex and Cedar Rivers would be 17 percent and 14 percent respectively, which would be too steep for fish to ascend in most cases. These steep areas are exposed as reservoir levels drop below about 1,540 initially. However, lake levels have not dropped this low since 1991. When the reservoir does drop this low, the duration is typically short (i.e., less than 1 to 2 weeks) so impedance would be minimal (City of Seattle, 1998). Additionally, as water levels drop, the rivers likely cut newer, less steep channels in the delta sediment that would aid fish passage. However, the process of delta erosion could increase suspended sediment and turbidity, causing delays of upstream migrations for those salmonid, that are known to avoid movement when turbidity levels are very high. The number of bull trout entering tributaries for spawning may be reduced under minimum pool operational scenarios.

Inundation of Spawning Areas

Changes in water depth and hydraulic conditions at spawning sites used by bull trout may occur related to the current operation of Chester Morse Lake. These changes occur as lake levels increase during early spring and inundate redds that were established in channels during the fall drawdown period. If redds are covered by rising waters prior to fry emergence, reduced water velocity may affect survival of fry in the redds. Effects depend on the timing, duration of lake water cover and the relative reduction in water velocity over the redds. Significant reduction in velocity would affect oxygen supply to the eggs or fry in the redds. Bull trout in the Watershed spawn during October into December, with fry emergence from late March into early June. Most of the emergence in the Cedar River occurs prior to the end of April, but peak emergence in the Rex River occurs later possibly due to cooler temperatures, extending into early May.

Some of the spawning areas in the Cedar and Rex Rivers are in regions that can be flooded during high lake levels, especially in the Rex River. Because water levels occasionally rise in the winter during storm events and every spring during snow melt, these regions are occasionally flooded at some time during egg incubation. A lake level of 1,555 feet is considered to be the lowest level with potential to adversely affect redds in the Cedar River (R2 Resource Consultants, in preparation). Based on available survey data collected during 1993 (R2 Resource Consultants, in preparation), lake levels of 1,555 feet would potentially affect redds only in the Rex River, as those in the Cedar

River were all at higher elevations. Water levels above 1,560 feet may affect a small portion of Cedar River redds (about 10 percent of those observed in 1993). Exceedance of the 1,560 feet lake elevation occurs only during mid-May under current normal operation (based on data from 1988 through 1995) after the majority of fry emergence has occurred in the Cedar River. At highest reservoir operation levels (1,563 feet), a significant portion of Cedar River redds would be inundated (about 35 percent of those observed in 1993).

In the Rex River, 95 percent of the observed redds in 1993 would be inundated at elevations of 1,557 feet pool level. Lake level records during 1988 to 1995 indicate that during April or May water levels exceeded 1,557 feet elevation 8 of the 9 years. Only 2 of 40 redds were situated above the 1,557 feet level

Because most emergence in the Cedar River likely occurs prior to the end of April, and most redds are at relatively high elevations, few adverse effects to bull trout eggs or fry from rising water levels are expected to occur in this system. However, Rex River emergence may be affected because of lower redd elevations and emergence extending into May. But available data are not sufficient to determine the effects on emergence from lake level changes. Overall, effects on eggs and fry survival in redds in both systems remains unknown.

The chance of rainbow trout redds being affected by lake level changes is less than it is for bull trout. Rainbow trout are spring spawners and typically spawn during a period of high lake level which would result in redd selection upstream of inundation areas. However, the higher lake levels may reduce the availability of suitable spawning sites, possibly causing fish to select less desirable spawning gravels for redd sites.

Egg incubation for pygmy whitefish, which occurs in the winter, lasts only a few weeks at most. This short incubation period should help reduce effects of lake level changes on incubation success for any pygmy whitefish that spawn in the lower regions of the rivers.

Stream Habitat of the Municipal Watershed

The Municipal Watershed contains approximately 90 miles of stream known or suspected to be inhabited by salmonids (Water Types 1, 2, and 3). An additional 308 miles of stream are not suspected to contain salmonids due to high gradients and size (Water Types 4 and 5), but may influence water quality in fish-bearing streams.

The Municipal Watershed encompasses a wide diversity of landforms. The Watershed was subdivided into three parts due to the distinctly different geomorphic history in each part. The “Central Cascade Mountain Terrain” consists of steep, mountainous topography and includes the area upstream of the Masonry Dam. It is underlain by volcanic and intrusive rocks, with alpine glacial deposits in the cirque basins and alluvium in the larger valley bottoms.

The “Glacio-fluvial Terraces” includes the area of the lower river affected by successive advances and retreats of the continental ice sheet. Thick deposits of recessional outwash and ice-contact deposits create gently sloping terraces in this part of the Watershed. Outwash deposits are also deposited onto moderate to steep slopes in this portion of the Watershed. The Taylor Creek basin, the third geomorphic division, is situated along the interface of the Mountainous and Terrace terrain.

Stream channels and fish habitat are shaped by inputs of water, sediment, and woody debris over time. Stream channels formed and maintained by similar fluvial and geomorphic processes have been partitioned into 23 valley segments within the Cedar River Watershed. The valley segment typing system provides a context for evaluating the effects of past and proposed forest management alternatives as well as for identifying restoration and protection opportunities. Descriptions of each valley segment type, the distribution across the Watershed, and the potential responses to natural and management influenced changes are provided in the Stream Channel and Fish Habitat Assessment (Foster Wheeler Environmental Corporation, 1995c).

Technical Appendix 15 provides an overview of the dominant factors that influence fish habitat in the 24 subbasins of the Watershed. Technical Appendix 15 is not intended to be an exhaustive disclosure of the basin conditions. Further elaboration is provided in the document entitled *Basin Condition Reports, Prescriptions, and Restoration Opportunities* (Foster Wheeler Environmental Corporation, 1995a).

Migration Barriers Associated with Roads

Since timber harvest and associated roading practices began, improperly designed stream crossings have resulted in numerous impediments to upstream fish migration in the Watershed. With over 580 miles of roads in the Watershed, the presence of roads across streams is common. The SPU conducted a survey of 168 crossing structures over potential fish-bearing streams and found that a large percentage may be obstacles to fish passage (SPU, 1998). Most of the barriers are due to culvert structures. Efforts are ongoing to determine the presence of fish in the affected streams and evaluate the availability of habitat upstream of the culvert barriers.

Role of Disturbances in Shaping Fish Habitat

Habitat Forming Processes

Under a natural disturbance regime, the condition of freshwater habitats for salmonids was regulated by episodic delivery of sediment and wood to the channel. Recruitment mechanisms include landsliding, windthrow, channel and bank erosion, and channel avulsion. Timber harvest activities, post harvest and silvicultural treatments, and fire suppression has clearly altered the natural disturbance regime and the recruitment of wood and sediment to stream channels.

Sediment Delivery. Disturbances characteristic of upland ecosystems, such as fire, windthrow, and large landslides, as well as disturbance processes unique to stream systems, such as channel erosion, floods, and debris flows, influence the delivery of sediment to fish-bearing streams. Although only a small percentage of the total land base is affected by mass wasting and surface erosion in the Watershed, a large proportion of the stream system can be affected by erosion and subsequent sediment delivery. Timber harvest and roading can influence the rate of surface erosion by exposing mineral soil or reducing slope stability through a variety of mechanisms as described in the Soils and Geology section. These activities can in turn alter the volume, timing, and grain size of sediment delivered to fish habitat.

Landslides are most common in over-steepened inner gorges, and are associated with both mature forest and clear-cut areas. For instance, steep forested slopes adjacent to Rack Creek and Bear Creek have contributed substantial amounts of sediment and wood to the system, which is deposited in their fish-bearing alluvial segments. Debris flows have also initiated in headwaters of low-order channels throughout the Watershed, and are commonly associated with clear-cut harvest to streamside. Portions of Boulder Creek, Middle and North Fork Taylor Creek, and subbasins to the north shore of the Chester Morse Lake contain prominent examples of channels influenced by debris flows associated with roads and timber harvest. Conditions in many of the high gradient, confined channels of these basins are indicative of major sediment routing flows, whereas habitats within the alluvial fish-bearing reaches have been widened and simplified. Later remobilization of previous debris flow deposits during high flows has been found to be a common source of localized channel widening in the upper Cedar River and Taylor Creek subbasins.

Road networks are a major source of management-related sediment delivery to fish habitat in the watershed. Road surface erosion can be a major nonpoint source of fine-grained sediments, and mass wasting due to poor road design or location can contribute large quantities of both coarse- and fine-grained sediment. Notable road-related failures that directly impact bull trout spawning habitat include steep roads north of the Cedar River directly above Chester Morse Lake. The valley walls of Boulder Creek are also chronic sediment sources via culvert and road failures. Extended riffles, development of large bars, and braiding have resulted in simplified habitat conditions downstream of these areas.

Much of the timber harvest and road construction that triggered accelerated sediment delivery to these streams was conducted under a variety of landowners and under outdated Federal or State forest practice guidelines.

Flow Regimes. Fish are adapted to natural variations in flows but may be adversely affected by disturbances that alter flow regimes. Forest practices can change the magnitude and timing of stream flow. Research results suggest that clear-cut logging can alter snow accumulation and melt enough to increase the size of peak flows caused by snowmelt during rainfall (Harr, 1986; Coffin and Harr, 1992). Increased peak flows may increase bed load movement and reduce survival of salmonid eggs and alevins, especially for fall spawning salmonids. These changes gradually diminish over time as vegetation regrowth occurs. The longevity of these changes is generally on the order of two to three decades.

Much of the watershed is situated within the transient snow zone and the snow zone, where peak flows have the highest likelihood of being augmented by ROS processes. The hydrology analysis conducted during the Watershed Assessment indicated that the existing level of timber harvest in Rack Creek, North Fork Taylor Creek and Middle Fork Taylor Creek could have increased the frequency and magnitude of peak flows. Each of these stream systems have also seen substantial inner gorge landslide and debris flow activity. Increased peak flows could potentially result in erosion of the unconsolidated bank material and toeslope cutting of oversteepened inner gorge slopes.

Historic aerial photos from 1958 through 1991 revealed numerous changes in channel pattern, width, or location within stream channel segments in most subbasins in the Taylor Creek and the Cedar River Watershed upstream of Chester Morse Lake during the 33-year period of record (Foster Wheeler Environmental, 1995c). Most of this activity was directly related to debris flows and associated channel widening. While a series of peak flows during this time may have contributed to the disturbance, the extent to which these peaks were influenced by timber harvesting remains unknown.

Riparian Functions. Vegetation within riparian areas regulates the exchange of sediment and organic material from upland forest to streams. Riparian vegetation also moderates energy inputs from sunlight, which influence biological processes. Root systems stabilize banks, allow development and maintenance of undercut bank habitat, and protect bank structure during peak flow events. Riparian vegetation also contributes leaves, twigs, and other forms of litter that are an important component of the food base upon which salmonids depend. Historically, riparian ecosystems within the Cedar River Watershed contained large conifers or a mix of conifers and hardwoods. The two riparian functions that have been clearly demonstrated to affect fish habitat and populations are regulation of stream temperature and recruitment of large woody debris.

<u>Stream Temperature.</u> Riparian vegetation provides shade along fish-bearing streams and smaller tributary streams that supply cool water to fish-bearing streams. Timber harvest has the potential to seasonally elevate stream temperatures if streamside shading is reduced. Buffer width correlates well with degree of shade (Beschta et al., 1987). In the western Cascade Mountains

stream buffers of 100 feet or more have been reported to provide as much shade as undisturbed late successional/old growth forests (Steinblums, 1977).

Past timber harvest in riparian areas has reduced shading in many areas of the Cedar River Watershed and may have locally contributed to increased stream temperature. However, subsequent forest regrowth has helped to reestablish forest canopy closure over many of the streams and riparian areas. Elevated stream temperatures have not been identified as a concern. Nearly all of the streams in the Cedar River Watershed meet or exceed target shade levels as established by the State Forest Practices Rules - Temperature Screen, in part due to tall shrubs providing effective cover. The higher elevations in the upper reaches of the watershed ensure stream temperatures remain below harmful levels, even though forest canopy may be sparse. Stream reaches that have undergone dramatic widening due to sediment delivery from upstream landslides, such as lower Boulder Creek and portions of Middle Fork Taylor Creek, are the few areas that sparse canopy closure may be adversely influencing stream temperatures.

<u>Large Woody Debris</u>. Down logs are an important component of many streams in the watershed. Large woody debris (LWD), consisting of trees and tree pieces that have fallen into a stream, can be a key component of salmonid habitat. This material provides cover for juvenile and adult fish, and is the primary pool-forming element in some channel types, particularly in alluvial channels dominated by gravels and cobbles. LWD influences the form and structure of a channel by affecting the profile of a stream, pool formation, and channel pattern. The rate at which sediment and organic matter are transferred downstream is controlled in part by woody debris. LWD may enter streams directly from the adjacent riparian stand or be transported from upstream sources during floods or debris flow events. LWD is also transported to streams from hillslopes via landslide processes.

Past management practices in the Cedar River Watershed have reduced the amount of LWD in some streams. Stream cleaning operations typically removed dense accumulations of wood from streams following felling and yarding activities. Many riparian areas in the watershed are just now becoming reestablished as adequate sources of LWD. Timber commonly was harvested to the edge of the streams in the earliest logging entries and up until the early 1980s. On fish-bearing streams, narrow strips of riparian vegetation designed to protect the streams were retained. These narrow buffer strips are susceptible to windthrow due to the edge effect created by the removal of surrounding forest and often shallow rooted trees in these areas of high water table.

Fisheries Habitat Downstream of the Landsburg Diversion

Currently, anadromous fish use only a portion of the Cedar River watershed downstream of Landsburg Diversion Dam and the Walsh Lake basin. As indicated above, major anthropogenic changes have affected the Cedar River.

In addition to rerouting the mouth of the river from the Green River to Lake Washington, changes have resulted from the increased development and urbanization of the lower river. These changes include forest clearing for agriculture, road and railroad construction, coal mining, and homesteading (King County Department of Public Works, 1993). Major modifications to the river included dike construction, channel straightening, bank stabilization using revetments, and bridge construction. Because of these activities, the width of the lower river has narrowed substantially from an estimated average width of 250 feet in 1865 to the current average width of 110 feet (King County Department of Public Works, 1993). The morphologic alterations to the river have substantially increased the frequency of scour events over historic patterns because lower flows can produce sufficient water velocities to initiate scour.

The Cedar River basin downstream of Landsburg includes 14 subbasins ranging from 140 to 7,695 acres in size (King County Department of Public Works, 1993). The Walsh Lake subbasin has been substantially modified by SPU. Historically, Walsh Lake drained into Rock Creek, a tributary to the Cedar River upstream of Landsburg Diversion. Near the turn of the century, extensive cattle pastures and a brick manufacturing plant in the Walsh Lake area resulted in water unsuitable for drinking purposes. Consequently, the Walsh Lake Ditch was built during the 1920s and 30s to divert this water to a location downstream of the Landsburg diversion. Although water quality has improved in Walsh Lake following changes in land use, the ditch remains as a legacy of these activities. The upper part of the ditch (River Mile 0.8 to 4.1) is mostly channelized and provides little fish habitat. The lower reach has two distinctive sections. From River Mile (RM) 0.18 to 0.65, the ditch is relatively steep with active downcutting, creating banks as high as 40 feet in some places (King County Department of Public Works, 1993). However, some areas have stabilized and developed many stream-like qualities, including the presence of relatively coarse boulder and cobble substrates and LWD. The lowermost section (RM 0.0 to 0.41) has a moderate gradient and meandering channel, but contains little LWD and goes subsurface during low-flow periods.

Recent surveys in Walsh Lake and its major perennial tributary, Webster Creek, indicate at least 11 fish species are present in the Walsh Lake basin (SPU, 1998; Technical Appendix 23). Two of the species, largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*), are not native to the region. Two additional species, kokanee (*O. nerka*) and coho salmon (*O. kisutch*), were not previously confirmed to inhabit the basin. The presence of coho salmon indicates the Walsh Lake Ditch is passable by anadromous fish during a portion of the year. Adult sockeye, chinook, and steelhead have been reported to use the lowest reach of Walsh Lake Diversion below the partial barrier at RM 0.8 (King County Department of Public Works, 1993).

In concert with stream channel modifications, the riparian zone along the Cedar River downstream of Landsburg has been substantially reduced (King

County Department of Public Works, 1993). The existing riparian stands are primarily deciduous trees in contrast to the historic predominance of conifers. Instream LWD is an important component to salmonid habitat (Bisson et al., 1987). LWD typically consists of fallen trees that may have their root wad attached. In low-gradient stream reaches, most instream LWD is derived from riparian zones through stream meandering and bank cutting. Alternatively, it floats into a reach from areas higher in the basin (Harmon et al., 1986). Among other things, LWD creates pools, stores sediment, and provides fish cover and substrate for aquatic invertebrate forage species. Conifers are generally preferred over deciduous species as instream LWD because they can be larger and decay at a slower rate (Harmon et al., 1986). As a result of fewer riparian zone tree stands and LWD removal, instream LWD is relatively sparse in the lower Cedar River. However, from a public works perspective, loss of instream LWD can be beneficial because floating LWD can damage bridges and revetments and provide hazards to recreational boaters.

The low level of LWD in the lower river has probably contributed to the reduction in the number of pools relative to unmanaged conditions. Pools are an important habitat type for rearing salmon and trout (Platts et al., 1983) and for use as adult holding areas. Estimates by King County suggest that the lower Cedar River would have approximately 9.6 large pools per mile of stream under pristine conditions (King County Department of Public Works, 1993). However, large pools occur at a density of 0 pools per mile between RM 0.0 and RM 1.6, 2.6 pools per mile between RM 1.6 to RM 14.8, and 3.9 pools per mile between RM 14.8 to RM 21.6 (King County Department of Public Works, 1993). These values suggest that urbanization may be a contributor to the current fish habitat conditions in the lower Cedar River.

King County has developed a plan to address surface water, groundwater, and fish habitat conditions in the lower Cedar River basin downstream of the Landsburg diversion (King County Department of Natural Resources, 1996). Components of the plan include the following:

- purchase of homes at risk to floods
- levee, revetment, and drainage modifications
- purchase and protection of high-quality fish habitat and wetlands
- aquatic habitat enhancement and restoration projects
- support of Lake Washington ecological studies
- technical assistance to septic tank and livestock owners
- tax relief and technical assistance to landowners with forested property
- stormwater and erosion control measures
- cooperative funding and implementation of habitat protection and restoration projects with city, state, and federal agencies.

All of the anadromous fish must pass through Lake Washington on their migrations to and from the marine environment. In addition, sockeye juveniles rear for up to 14 months in Lake Washington. The utilization of the lake for rearing by coho salmon, chinook salmon, steelhead trout, and sea-run coastal cutthroat is poorly understood. Lake Washington is a highly productive lake (Brannon, 1983) with a complex planktonic and fish ecology that includes both native and introduced fish (Edmondson, 1983; Brannon, 1983). The population size and composition of planktonic species have had dramatic shifts over the years because of urbanization and changes in sewage management strategies (Edmondson, 1983). Not only have long-term changes occurred in the lake, but seasonal and annual fluctuations also occur on a more or less regular basis. The capacity of Lake Washington to sustain large numbers of rearing juvenile sockeye salmon is unknown. However, the lake is known to produce some of the largest sockeye smolts in the world (Burgner, 1991).

Instream Flows

One aspect of fish habitat in which SPU plays an important role is instream flows for the fisheries resources. Discussion of other non-fish-related water issues are present in Section 3.2 (Water Quality and Quantity). Instream flows interact with the channel morphology to produce fish habitat. Important components to channel morphology include its gradient, geology, riparian condition, and roughness from coarse sediment (i.e., boulders, cobbles, etc.) and LWD. These components provide habitat complexity and a wide variety of physical conditions conducive to a diverse and productive fish fauna. As described earlier, the salmon, trout, and other fish species have specific requirements and preferences for water depths and velocities that are often found in habitat types described as runs, riffles, pools, etc. The location, quantity, and quality of the habitat types is dynamic. For example, as instream flows rise and fall, pools may look more like runs and vice versa. Furthermore, the amount of wetted area in a channel is substantially different at different flows. Instream flows also provide a transport mechanism during periods of outmigration.

The Instream Resource Protection Program (IRPP) was developed in 1979 to determine minimum instream flow needs. The IRPP resulted in the current nonbinding minimum instream flows provided voluntarily by the applicant and measured at Renton. During a year with normal precipitation levels minimum flow requirements range from 130 to 370 cfs depending upon the time of year. No minimum instream flows are currently required upstream of the Landsburg Dam.

The IRPP flows were developed near the end of the latter of two instream flow studies. The first study was conducted by the USGS and WDF between 1967 and 1969 (Collings et al., 1970, as cited in Columbia Environmental Services, 1991). Between 1972 and 1980, a second instream flow study was conducted by the University of Washington’s Fisheries Research Institute under contract to the Seattle Water Department. Concerns over the appropriateness of the IRPP flows resulted in a third effort to determine the instream flow requirements for selected fish species. Consequently, a 10-year collaborative study program was funded by SPU. The program has been directed by the Cedar River Instream Flow Committee (CRIFC) consisting of SPU, the Washington Department of Fish and Wildlife, the Washington State Department of Ecology, the Army Corps of Engineers, the U.S. Fish & Wildlife Service, the National Marine Fisheries Service, and the Muckleshoot Indian Tribe. The program included four major study components: an Instream Flow Study, an Effective Spawning Analysis, a Cumulative Spawning Analysis, and a Risk Zone Analysis.

The results of the Instream Flow Incremental Methodology (IFIM) and associated studies suggested that some improvements over the IRPP flows were possible for both increasing the available habitat and improving incubation conditions. A comparison of the nonbinding IRPP flows and the likely improvements under the applicant's proposal will be discussed under the Environmental Effects section. Included in this discussion will be additional details describing the IFIM and associated studies.

Mitigation Goal for Sockeye

An 11.1-mile reach of the Cedar River was surveyed by a multiagency team from Cedar Falls to Landsburg during June 1977. The objective was to determine the potential amount of sockeye spawning habitat that would be available if fish could access the reach above the Landsburg Diversion (WDFW, 1997a and b) Technical Appendix 4 provides details on the survey methods and results. The investigation was conducted as an activity of the Cedar-Tolt Watershed Advisory Committee which eventually became the Cedar River Technical Committee. Using small-scale maps (1:4,800), the reach was divided into 11 segments. For each segment, stream width was measured and the percentage of stream bottom suitable for spawning was estimated based upon professional judgment.

The survey team determined the overall reach could be divided into two sub-reaches at the confluence of Taylor Creek. Flows were substantially higher in the 7.1-mile downstream subreach due to inflows from groundwater seepage, Taylor Creek, and other smaller streams. In addition, the 4.0-mile upper reach was steeper, narrower, and contained coarser substrate. Overall, their assessment was that the upper subreach was less suitable for sockeye spawning than the lower subreach.

The calculations in 1977 indicated that 26,200 yds^2 and 123,300 yds^2 of spawning habitat were available in the upper and lower subreaches, respectively (WDFW, 1997a). The original Cedar River Sockeye Technical Committee decided to use a spawner density of one female per yd^2 based upon information from the Fraser River in British Columbia and the average size of Cedar River sockeye relative to sockeye typical of the Fraser River. Females account for 57 percent of the lower Cedar River spawning population. Consequently, the total potential spawning stock for the upper Cedar River was estimated as 262,000 sockeye. This value was used as the basis for legislation passed in 1989 (Senate Bill #5156) that established the mitigation goal for the sockeye salmon migration barrier created by the Landsburg Diversion Dam. Similar field studies and calculations have not been conducted for steelhead trout, chinook salmon, or coho salmon. As indicated earlier, the applicant, the Muckleshoot Indian Tribe, and State and Federal agencies have not agreed on numeric mitigation goals for these species. Upstream and downstream passage facilities and intake screening facilities designed and operated under State criteria are considered full mitigation for these species.

3.4.3 Summary

The main points presented above include the following:

- The Landsburg Diversion Dam currently blocks the upstream passage of chinook salmon, coho salmon, sockeye salmon, and steelhead trout.
- Current instream flow regimes in the Cedar River downstream of the Landsburg Diversion were developed by the Instream Resource Protection Program (IRPP) and are nonbinding.
- There are currently no instream flow requirements upstream of Landsburg Diversion.
- The population status of chinook salmon, coho salmon, sockeye salmon, and steelhead trout is depressed. Chinook salmon is proposed for listing as a threatened species under ESA. Coho is listed as a candidate species. Factors that are likely to contribute to depressed conditions include urban development, channel and floodplain modifications, poor conditions in Lake Washington, poor ocean conditions, habitat destruction, low passage survival at Chittenden Locks, overfishing, and instream flows.
- Coho salmon, chinook salmon, sockeye salmon, and steelhead trout have different strategies for utilizing the freshwater habitat for rearing. Coho salmon and steelhead trout rear in the Cedar River for one or more years, but preferentially utilize different microhabitats. Sockeye salmon rear in Lake Washington for up to 14 months. Chinook salmon migrate to Puget Sound during their first year of life.
- A prototype sockeye hatchery facility was built in 1991. Production capacity has been gradually increased from 2 million to 16 million fry.
- Genetic studies suggest the sockeye salmon population was introduced from the Baker River stock. Substantial hatchery plants have also occurred in the past for chinook salmon, coho salmon, and steelhead trout and kokanee salmon.

- The state has estimated that habitat upstream of Landsburg Dam would have the capacity for 262,000 spawning adult sockeye salmon. This is the basis for the sockeye mitigation goal legislated by the state.
- Infectious Hematopoietic Necrosis Virus (IHNV) is present in nearly all naturally reproducing sockeye including the population that spawns in the Cedar River. Alaska sockeye salmon culture protocols (McDaniel et al., 1994) have been employed at the prototype hatchery for the past seven years to effectively manage the risks associated with IHNV and prevent the release of infected fry into the system.
- The City co-funds the Lake Washington ecological studies designed to investigate potential limiting factors to sockeye smolt production such as competition for the zooplankton forage resources and predation by trout and other piscivores.
- Three separate studies have been conducted since 1967 to determine instream flow requirements for the Cedar River below Masonry Pool. The most recent set of studies were conducted in collaboration with state, federal and tribal resource managers, utilized the IFIM developed by the FWS and included several additional companion studies to investigate a number of key topics that are not typically addressed by IFIM.
- Redd scour has been identified as a significant factor negatively affecting sockeye egg survival during periods of high flow.
- Healthy populations of resident salmonids are widely distributed in the Cedar River Watershed above the Landsburg Diversion. A self-sustaining population of kokanee occurs within the Walsh Lake basin.
- Coastal cutthroat and rainbow trout inhabit the waters of the Cedar River Watershed downstream of the Masonry Dam.
- Bull trout, rainbow trout, and pygmy whitefish occur within Chester Morse Lake/Masonry Pool and accessible tributaries.
- Viable populations of bull trout and pygmy whitefish, both species of greatest concern in the Watershed, inhabit Chester Morse Lake.
- Dynamic upslope and fluvial processes have created and maintain a diversity of fish habitats in the Cedar River Watershed. Past timber harvest and road building activities have altered the frequency and magnitude of channel disturbance processes that affect fish habitat.

Significant changes in the Cedar River downstream of Landsburg Diversion have resulted from the increased development and urbanization of the lower river. Major modifications to the river included dike construction, channel straightening, bank stabilization using revetments, and bridge construction.

3.5 Wildlife

The proposed Cedar River Watershed HCP (City of Seattle, 1998) addresses 83 animal species, including fish and wildlife resources, known or suspected to occur in the Cedar River Municipal Watershed. This section addresses the 72 non-fish taxa (subsequently referred to as "wildlife") covered by the proposed HCP. The 73 wildlife taxa of concern—which include a number of invertebrates, amphibians, reptiles, birds, and mammals—have been grouped into species assemblages (wildlife communities) according to key habitat(s) associations. Key habitat is defined as the habitat that is known or suspected to be the current major limiting factor for the species. This typically includes the breeding habitat if the species is known to breed in Washington or wintering or foraging habitat if the species is not known to breed in Washington. The three key habitats and their associated wildlife communities for the purposes of this discussion are defined as: (1) aquatic and riparian; (2) old growth forest; and (3) special habitats (Table 3.5-1).

In Section 4.5, alternatives are evaluated in relation to their effects on what is considered to be the key habitat for each species of concern or wildlife community, including effects on habitat fragmentation and connectivity. To provide a basis for understanding the evaluation of environmental consequences, this section briefly describes the three key wildlife habitats (including fragmentation and connectivity of old growth forest habitats), their associated wildlife communities, and the species of concern that make up each wildlife community. In addition, other wildlife habitats and species in the Cedar River Municipal Watershed are briefly discussed. Finally, the significance of the Cedar River Municipal Watershed in regional habitat connectivity (i.e., west-central Cascade Mountains in Washington state).

3.5.1 Habitats

This section briefly describes the characteristics of the three key wildlife habitats (aquatic and riparian, old growth forest, and special habitats) and other wildlife habitats in the Cedar River Municipal Watershed. Acreages of key wildlife habitats in the Cedar River Municipal Watershed are presented in Table 3.5-2.

Table 3.5-1. Key wildlife communities and constituent species of concern in the Cedar River Watershed HCP (page 1 of 2)

I. AQUATIC AND RIPARIAN COMMUNITY

Species	Latin Name
Beller's Ground Beetle	*Agonum belleri*
Hatch's Click Beetle	*Eanus hatchii*
Long-horned Leaf Beetle	*Donacia idola*
Carabid Beetle	*Nebria paradisi*
Carabid Beetle	*Nebria gebleri cascadensis*
Carabid Beetle	*Nebria kincaidi*
Carabid Beetle	*Omus dejeanii*
Carabid Beetle	*Bemdidion viator*
Carabid Beetle	*Bembidion gordoni*
Carabid Beetle	*Bembidion stillaquamish*
Carabid Beetle	*Pterostichus johnsoni*
Carabid Beetle	*Bradycellus fenderi*
Fender's Soliperlan Stonefly	*Soliperla fenderi*
Papillose Taildropper	*Prophysaon dubium*
Snail	*Valvata mergella*
Van Dyke's Salamander	*Plethodon vandykei*
Northwestern Salamander	*Ambystoma gracile*
Long-toed Salamander	*Ambystoma macrodactylum*
Pacific Giant Salamander	*Dicamptodon tenebrosus*
Cascade Torrent Salamander	*Rhyacotriton cascadae*
Western Redback Salamander	*Plethodon vehiculum*
Roughskin Newt	*Taricha granulosa*
Western Toad	*Bufo boreas*
Tailed Frog	*Ascaphus truei*
Red-legged Frog	*Rana aurora*
Oregon Spotted Frog	*Rana pretiosa*
Cascades Frog	*Rana cascadae*
Western Pond Turtle	*Clemmys marmorata*
Common Loon	*Gavia immer*
Harlequin Duck	*Histrionicus histrionicus*
Great Blue Heron	*Ardea herodias*
Osprey	*Pandion haliaetus*
Bald Eagle	*Haliaeetus leucocephalus*
Willow Flycatcher	*Empidonax traillii*
Northern Water Shrew	*Sorex palustris*
Masked Shrew	*Sorex cinereus*
Johnson's (mistletoe) Hairstreak	*Mitoura johnsoni*

Table 3.5-1. Key wildlife communities and constituent species of concern in

II. OLD-GROWTH FOREST COMMUNITY

Species	Latin Name
Blue-gray Taildropper	*Prophysaon coeruleum*
Puget Oregonian	*Cryptomastix devia*
Oregon Megomphix	*Megomphix hemphilla*
Marbled Murrelet	*Brachyramphus marmoratus*
Northern Spotted Owl	*Strix occidentalis*
Northern Goshawk	*Accipiter gentilis*
Three-toed Woodpecker	*Picoides tridactylus*
Pileated Woodpecker	*Dryocopus pileatus*
Olive-sided Flycatcher	*Contopus borealis*
Brown Creeper	*Certhia americana*
Vaux's Swift	*Chaetura vauxi*
Canada Lynx	*Lynx canadensis*
Fisher	*Martes pennanti*
Marten	*Martes americana*
Hoary Bat	*Lasiurus cinereus*
Big Brown Bat	*Eptesicus fuscus*
Silver-haired Bat	*Lasionycteris noctivagans*
Long-eared Myotis	*Myotis evotis*
Long-legged Myotis	*Myotis volans*
Fringed Myotis	*Myotis thysanodes*
California Myotis	*Myotis californicus*
Little Brown Myotis	*Myotis lucifugus*
Yuma Myotis	*Myotis yumanensis*
Keen's Myotis	*Myotis keenii*
Townsend's Western Big-eared Bat	*Plectotus townsendii*

III. SPECIAL HABITAT COMMUNITY

Species	Latin Name
Larch Mountain Salamander	*Plethodon larselli*
Band-tailed Pigeon	*Columba fasciata*
Rufous Hummingbird	*Selasphorus rufus*
Golden Eagle	*Aquila chrysaetos*
Merlin	*Falco columbarius*
Peregrine Falcon	*Falco peregrinus*
Black Swift	*Cypseloides niger*
Western Bluebird	*Sialia mexicana*
Grizzly Bear	*Ursus arctos*
Wolverine	*Gulo gulo*

Table 3.5-2. Key wildlife habitats in the Cedar River Municipal Watershed

Habitat Type	Total Acreage
Aquatic and Riparian Habitats	
Open Water	2,214
Palustrine Emergent Wetlands	236
Palustrine Scrub-Shrub Wetlands	464
Forested Wetlands	1,063
Aquatic and Wetland Complex	6,431
Riparian Vegetation Zones	4,223
Old-Growth Forest Habitats	
Old-Growth Forest	13,889
Special Habitats	
Rock Outcrops and Cliffs	54
Talus/Felsenmeer	1,518
Upland Grass-Forb Meadows	110
Upland Persistent Shrub	93
Unclassified Non-forested Habitat	33

Aquatic and Riparian

Aquatic habitats, as used here and in the proposed HCP, are "habitats…within water courses such as lakes, ponds, rivers, streams, marshes, and wetlands" (City of Seattle, 1998). Aquatic wildlife habitats (i.e., habitats for non-fish species) include open water bodies (lakes, ponds, etc.) and wetlands (palustrine emergent wetlands, forested wetlands, palustrine scrub-shrub wetlands). The location of aquatic habitats within the proposed HCP planning area is shown on Resource Map 5.

Rattlesnake Lake and Walsh Lake are the dominant open-water bodies in the lower municipal watershed (although Rattlesnake Lake is outside the hydrographic boundary of the Watershed, there is a subsurface groundwater flow connection to the Cedar River), while Chester Morse Lake and the Masonry Pool are the dominant open water bodies in the upper municipal watershed. In addition, several small lakes, ponds, and unnamed bodies of open water are scattered over the higher-elevation landscape within the upper municipal watershed. The principal of these is Findley Lake.

There are two principal wetland systems in the lower municipal watershed—a small scrub-shrub system between Williams and Rock Creeks near the northern boundary and a larger, more complex system surrounding and east of Walsh Lake. In the upper municipal watershed, wetland habitat types are numerous (e.g., sedge-covered delta areas, sphagnum bogs, sedge-dominated wetlands, and upland wet meadows), vary widely in size, and are distributed throughout the landscape, encompassing nearly the entire elevation range of the upper watershed. A major wetland and aquatic complex occurs along the Cedar River just upstream from Chester Morse Lake, along the Rex River, and in drainages that connect the Cedar River with the Rex River south of Little Mountain.

Riparian habitats, as used here and in the proposed HCP, are "terrestrial habitats…along water courses" (City of Seattle, 1998). Riparian habitats occur along water courses throughout the lower and upper municipal watershed and are primarily contained within stream, lake, and wetland buffers (Resource Map 16). Approximately 720 acres of riparian vegetation occurs in scattered areas in the lower and upper municipal watershed (Resource Map 5).

Old-Growth Forest

Old-growth forest habitats, as used here and in the proposed HCP, are "habitats associated with forests having the following characteristics: high degree of vertical and horizontal structural development; large trees greater than 20 inches dbh (diameter breast height); mixture in tree species; multilayer canopy with gaps; and snags and downed logs" (City of Seattle, 1998). These old growth habitats are considered to be "unharvested native forest 190 years or older" (City of Seattle, 1998). The location of old growth forest habitat within the proposed HCP planning area is shown on Resource Map 5.

Currently, there are 13,889 acres of old growth in the Cedar River Municipal Watershed (see Table 3.3-1) and most of this can be found in the upper municipal watershed. Most of this old growth forest in the upper municipal watershed is between 190 to 350 years old, but a few scattered stands, particularly in the upper Rex River basin, contain individual trees up to 850 years of age. Although all of these stands may be referred to as old growth from the perspective of chronological age, they vary widely relative to the extent of development of both vertical and horizontal structural components (i.e., classic old growth characteristics) (City of Seattle, 1998). Individual stands exhibiting a high degree of classic old growth characteristics are present in (1) the upper Rex River basin, (2) the North Fork of the Cedar River drainage, and (3) the area surrounding Goat Mountain (City of Seattle, 1998).

Special Habitats

Special habitats, as used here and in the proposed HCP, are "special habitat features (e.g., caves, cliffs, talus/felsenmeer, meadows, and mineral springs)," "other identified rock habitat," and "any active nesting and denning site(s) or other critical habitat of a federal or state, Threatened and Endangered (T&E) listed upland vertebrate species. . . during the active nesting or denning season" (City of Seattle, 1998). The location of these habitats within the proposed HCP planning area is shown on Resource Maps 5 and 16.

Talus is "angular rock fragments stacked against the cliff or steep slopes from which they have fallen," while felsenmeer is "a thin surface layer (from less than one meter to several meters) of stable, unvegetated, generally igneous rocks created by rockfall erosion from upslope near vertical cliffs" (City of Seattle, 1998). Talus and felsenmeer rock formations are prevalent on the steep slopes north of Findley Lake and on the south-facing slopes of Tinkham Peak at the northeast boundary. Rock outcrops and cliffs are evident in Seattle Creek basin, in the upper reaches of Rack Creek basin, and above Rattlesnake Lake. A third type of rock formation is represented by the sheer rock walls in the u-shaped glacial cirques of upper Goat Creek, Troublesome Creek, and Findley Lake basins.

All naturally occurring meadow habitats are included in this category. An area of upland shrub-forb meadow is located on the south-facing slope of Mt. Baldy on the northeast boundary of the Watershed. This habitat is uncommon within the Watershed.

Other Habitats

Other wildlife habitats in the Cedar River Municipal Watershed consist primarily of early seral-grass forb stage (0 to 29 years), early seral-open canopy stage (30 to 79 years), mid seral-closed canopy (80 to 119 years), and late successional forest (120 to 189 years) (see Section 3.3). At present, there are 15,610 acres of early seral forest, 54,592 acres of mid seral forest, 1,074 acres of mature forest, and 91 acres of late successional forest in the Watershed (Table 3.3-1 and Map 4).

The landscape of the lower municipal watershed is almost completely occupied by an essentially homogeneous, unbroken canopy of second growth coniferous forest (includes mixed conifer and deciduous species) which has regenerated since the original harvest of nearly all native forest stands in the area. Species composition of forest stands in the lower municipal watershed is dominated by Douglas-fir and western hemlock with both pure and mixed species stands represented. Mixed coniferous and deciduous stands are also present and are distributed across the landscape, mostly in forested wetland and riparian habitats. Pure hardwood stands are infrequent, found mostly in especially wet or riparian areas. The spatial distribution and condition of forest stands today basically reflects the pattern of logging activity (i.e., harvest of old growth forest) which began in the lower municipal watershed during the 1880s.

The earliest logging activity in the lower municipal watershed took place in the middle reaches of the Taylor and lowest reaches of the Walsh subbasins and in several areas both north and south of the mainstem of the Cedar River. The 71 to 90 year-old stands in these areas represent the most advanced second growth forest in the lower municipal watershed. Since soils within much of these areas provide moderate to high quality growing conditions, tree height, diameter, and development of ecological diversity (e.g., vertical and horizontal structure, snags) are substantially advanced in much of this forest. Most of the remaining forest stands in the lower municipal watershed are between 51 to 70 years old and are spread throughout the landscape, including both low and mid elevations. Forest development is well advanced in most of these stands (i.e., some self-thinning has taken place below the canopy, a limited understory is present in some stands, and a shrub layer is typically present). Forest stands 21 to 40 years of age are present mostly in the upper reaches of the Walsh and Taylor subbasins. These stands are typically dense with nearly complete canopy closure. A sparse to moderate shrub layer is present in many stands, but development of an herbaceous layer is typically lacking. In addition, approximately a dozen "bioforestry" units, completed since 1990, are present in the lower Taylor subbasin. These units have been replanted with multiple conifer species, and conifer regeneration is in various stages of development.

In the upper municipal watershed, second growth coniferous forest in the Chester Morse Lake basin ranges from 41 to 70 years old and has regenerated under a variety of growing conditions. This has produced stands with widely varying ecological structural development. Particularly notable among the variety of second growth stands in the upper municipal watershed are stands in the lower two-thirds of the Rex River drainage and lower Boulder Creek, most of which are 51 to 60 years of age. Most of these stands have a structure that is different from similar-age stands in other areas of the upper municipal watershed. Stands in this area are extremely dense with completely closed canopies that allow minimal light penetration. As a result, the stands are almost completely devoid of tree and shrub understory and herbaceous vegetation is almost nonexistent.

Second growth stands further east of Chester Morse Lake in areas adjacent to the mainstem and North and South Forks of the Cedar River represent a mixture of age classes ranging from 31 to 70 years. Most of this area, especially closer to the valley floor and riparian areas, has good growing conditions, and stands are well developed. Some of these stands are particularly dense, as neither self-thinning nor precommercial thinning has taken place. Many stands, especially on wetter soils and adjacent to small drainage systems, exhibit a significant deciduous component which typically decreases as slope and elevation increase.

With the exception of areas adjacent to the upper mainstem and North and South Forks of the Cedar River, the majority of commercial timber harvest in old growth forest within the upper municipal watershed during the last four decades and especially during the last 20 years has been concentrated above 2,500 feet elevation. Most of this area is in the upper reaches of drainage basins (e.g., Rack Creek, Boulder Creek, Lindsay Creek, and Rex River) or on the upper portions of steep slopes immediately adjacent to high elevation ridgelines (e.g., the north boundary ridge). These areas, most of which have been planted with conifer seedlings augmented by natural seeding and post-harvest release, exist today in various stages of regeneration. The degree of development and the present stand condition depends mainly on the soil types and climatic regimes present at specific sites.

3.5.2 Key Wildlife Communities and Species of Concern

This section gives brief natural history descriptions of the species of concern in each of the three key wildlife communities (aquatic and riparian, old growth forest, special habitats). Each description includes the species' designated status in Washington (based on City of Seattle, 1997 and 1998), general distribution within Washington, status in the Cedar River Municipal Watershed, and key habitat requirement.

Aquatic and Riparian

Thirty-eight wildlife species of concern are associated with the aquatic and riparian community. This community is dominated by aquatic invertebrates (16 taxa), amphibians (12 species), and birds (6 species). One reptile and three mammal species are also included.

Beller's Ground Beetle

Beller's ground beetle (*Agonum belleri*) is a federal species of concern (City of Seattle, 1998) and a state candidate species in Washington (WDFW, 1996). It occurs exclusively in lowland sphagnum bogs of Washington, Oregon, and southwestern British Columbia (Johnson, 1986). Sphagnum bogs below 1,000 m elevation are the key habitat. In Washington, Beller's ground beetle is only known to occur in Snoqualmie Bog, now a DNR natural area preserve (NAP), located along the North Fork of the Snoqualmie River, and in Kings Lake Bog NAP (Crawford, 1994).

Hatch's Click Beetle

Hatch's click beetle (*Eanus hatchi*) is a federal species of concern (City of Seattle, 1998) and a state candidate species in Washington (WDFW, 1996). It occurs exclusively in lowland sphagnum bogs or northwestern Washington (Johnson, 1979). Sphagnum bogs below 1,000 m elevation are the key habitat. This species is known to occur historically in Snohomish and King Counties, but is currently known to occur only at three bog sites in central King County, including Kings Lake Bog NAP (WDFW, 1994a; Crawford, 1994).

Long-horned Leaf Beetle

The long-horned leaf beetle (*Donacia idola*) is a state candidate species in Washington (WDFW, 1996). It occurs specifically in lowland sphagnum bogs of Washington and southwestern British Columbia (Rodrick and Milner, 1991). Sphagnum bogs below 1,000 m elevation are the key habitat. In Washington, this species has been documented historically only in Snohomish County, and is currently known to occur in only one locale: Chase Lake, near

Edmonds (R. Crawford, University of Washington, Seattle, personal communication, 1993 cited in WDNR, 1996).

Carabid Beetles

Nebria paradisi, *N. gebleri cascadensis*, *N. kincaidi balli*, *Omus dejeanii*, *Bembidion gordoni*, *B. stillaquamish*, and *Pterostichus johnsoni* occur in stream and streamside habitats; these are their key habitats in the Cedar River Municipal Watershed. *Bembidion viator* and *Bradycellus fenderi* occur in swamps and forested marshes; these are their key habitats in the Cedar River Municipal Watershed. The occurrence of these species in the Watershed is unknown.

Fender's Soliperlan Stonefly

Fender's soliperlan stonefly (*Soliperla fenderi*) is a federal species of concern. One specimen was collected from St. Andrew Creek in Mount Rainier National Park (J. Lattin, Oregon State University, Corvallis, personal communication, 1994 cited in WDNR, 1996). Based on the biology of related species of stoneflies, this species' key habitat requirements are assumed to occur within and adjacent to aquatic habitats. The occurrence of these species in the Watershed is unknown.

Papillose taildropper

The papillose taildropper (*Prophysaon dubium*) is usually found under logs and among leaves in riparian habitats; riparian areas and wetlands are key habitats in the Cedar River Municipal Watershed. The species has been reported from Thurston and Pierce Counties in Washington (Burke, 1994a). Recently, individuals have been found east of the Cascades, in moist, streamside habitats (Foster Wheeler Environmental field surveys, 1997; Burke, 1994a). The occurrence of this species in the Watershed is unknown.

Snail

The snail (*Valvata mergella)* occurs in lakes with mud bottoms and well oxygenated water. All lakes and aquatic habitats in the Cedar River Municipal Watershed are considered key habitats. The occurrence of these species in the Watershed is unknown.

Van Dyke's Salamander

Van Dyke's salamander (*Plethodon vandykei*) is a state candidate species in Washington (WDFW, 1996). Van Dyke's salamander is endemic to Washington (Leonard et al., 1993); approximately half of its known distribution is on the Olympic Peninsula. Key habitat for Van Dyke's salamanders is seepages, streams, and riparian areas located in mature and old growth coniferous forests. The species is typically located in the splash zone of creeks under rocks, logs, and wood debris (Leonard et al., 1993). The occurrence (i.e., presence or absence) of Van Dyke's salamander in the Cedar River Municipal Watershed is unknown.

Northwestern Salamander

The northwestern salamander (*Ambystoma gracile*) occurs from sea level up to about 3,100 m elevation in humid coniferous forests and subalpine forests (Nussbaum et al., 1983). In Washington, it occurs in the western Cascades (all lower elevation vegetation zones plus western hemlock and silver fir zones), in the Puget Sound lowlands, on the Olympic Peninsula, and in the southwestern part of the state (Dvornich et al., 1997). Rivers, streams, ponds, all wetland types, and riparian areas are considered key habitats in the Cedar River Municipal Watershed. This species is present and is known to breed in the Watershed.

Northwestern Salamander

Long-toed Salamander

The long-toed salamander (*Ambystoma macrodactylum*) occurs in a variety of habitats—sagebrush steppe, dry woodlands, conifer forests, alpine meadows—from sea level to about 3,000 m (Nussbaum et al., 1983). The species occurs throughout much of Washington except for the driest parts of the Columbia Basin (Nussbaum et al., 1983). It is also rare in or absent from most wet forest types of the western Cascades and Olympic Peninsula (e.g., western hemlock, silver fir, Sitka spruce), occurring only in isolated open areas that might have once supported west-side prairies or boggy meadows (Dvornich et al., 1997). Lakes, marshes, rivers, and riparian areas are considered key habitats for the long-toed salamander in the Cedar River Municipal Watershed. The species is present and is known to breed in the Watershed.

Pacific Giant Salamander

The Pacific giant salamander (*Dicamptodon tenebrosus*) is restricted largely to moist coniferous forests and mountain lakes and streams from sea level to 2,160 m elevation (Nussbaum et al., 1983). In Washington, it occurs in the Cascades primarily west of the Cascade Crest (below and including the western hemlock zone), in the east-central Cascades (western hemlock and interior western hemlock vegetation zones), in eastern Puget Sound lowlands, and in the southwestern part of the state. Rivers, streams, and riparian areas are considered key habitats for the Pacific giant salamander in the Cedar River Municipal Watershed. The species is present and is known to breed in the Watershed.

Cascade Torrent Salamander

The Cascade torrent salamander (*Rhyacotriton cascadae*) is a Washington State Candidate species. The Cascade torrent salamander occurs along the western slopes of the Cascade Range from northeastern Lane County, Oregon, north to the vicinity of Mount St. Helens, WA (Blaustein et al., 1995). Small cold streams with water seeping through moss-covered gravel are preferred habitats for torrent salamanders (Blaustein et al., 1995). Breeding habitat for these species is generally considered to be forested permanent seeps, streams, and waterfalls with rocky substrates and cold temperatures (optimum 8 to 13°C); foraging occurs in moist areas in or near streams and seeps (Corn and Bury, 1991; Leonard et al., 1993; Diller and Wallace, 1996; Welsh and Lind, 1996). Populations of this species are threatened by removal of riparian old-growth forests, changes in seep hydrology, and increased deposition of fine sediments in streams, primarily due to timber management activities (Corn and Bury, 1989; Jennings and Hayes, 1994). The presence and breeding status of this species in the Cedar River Watershed are unknown. Based on range and habitat availability, this species may potentially occur within the Cedar River Watershed.

Western Redback Salamander

The western redback salamander (*Plethodon vehiculum*) occurs primarily in dense forests from sea level up to 1,200 m (Nussbaum et al., 1983; Dvornich et al., 1997). In Washington it occurs in the western Cascades (below and including the western hemlock zone), on the Olympic Peninsula, and in the southwestern part of the state (Dvornich et al., 1997). It is common in talus slopes, but also occurs in leaf litter, under bark, and under other surface debris of the forest floor (Nussbaum et al., 1983). Conifer-lined riparian areas are considered key habitat for the western redback salamander in the Cedar River

Municipal Watershed. The species is present and is known to breed in the Watershed.

Roughskin Newt

The roughskin newt (*Taricha granulosa*) occurs in a variety of habitats in hilly or mountainous country from sea level up to 2,800 m (Nussbaum et al., 1983). In Washington, it occurs in the western Cascades (up to the silver fir zone), in the east-central and southeast Cascades (interior Douglas-fir, grand fir, western hemlock, and interior western hemlock zones), in the Puget Sound lowlands, on the Olympic Peninsula, and in the southwestern part of the state (Dvornich et al., 1997). Roughskin newts are most common in mesophytic forests of conifers or hardwoods, although they also occur in open valleys and farmland (Nussbaum et al., 1983). Key habitats in the Cedar River Municipal Watershed are lakes, ponds, sluggish streams, wetlands, and riparian areas. The species is present in the Watershed.

Western Toad

The western toad (*Bufo boreas*) is a federal species of concern. It occurs from southeast Alaska through British Columbia to northern California (ODFW, 1996). Populations have been declining; whole populations have been lost for unknown reasons in the Cascade range and elsewhere (Leonard et al., 1993; Corn, 1994). Western toads occur in forested and brushy areas from sea level to high mountains; moist areas with dense cover are considered optimal (ODFW, 1996). Western toads breed in springs, ponds, shallow areas in lakes, and slow-moving streams (ODFW, 1996). In the Cedar River Municipal Watershed, aquatic and riparian habitats are key habitats. The western toad has been documented breeding in the Watershed and is considered common there.

Tailed Frog

The tailed frog (*Ascaphus trueii*) is a federal species of concern and a state monitor species in Washington. Tailed frogs are adapted to cold, rocky streams in coniferous forest habitats (Leonard et al., 1993). Their tadpoles are highly specialized for living in fast-moving streams. Streams and riparian areas are key habitats in the Cedar River Municipal Watershed. The tailed frog is widely distributed in the Watershed and is known to breed there.

Red-legged Frog

The northern red-legged frog (*Rana aurora aurora)* is a federal species of concern. In Washington, it occurs in the western Cascades (all vegetation zones up to and including western hemlock), in the Puget Sound lowlands, on the Olympic Peninsula, and in the southwestern part of the state (Dvornich et al., 1997). Red-legged frogs are frequently found in old growth stands (Bury and Corn, 1988). In southern Washington, Aubry and Hall (1991) found that this species was most abundant in mature stands and least abundant in young stands. Key habitats for this species in the Cedar River Municipal Watershed are lower elevation moist and riparian forests, marshes, bogs, ponds, springs, seeps, and slow-moving streams. The species is widely distributed and is known to breed in the Watershed.

Oregon Spotted Frog

The Oregon spotted frog (*Rana pretiosa)* is a Federal Candidate Species and a state candidate species in Washington (WDFW, 1996). Historically, the Oregon spotted frog was distributed through the lowlands of the Puget Trough from the Canadian border south to Vancouver and east into the southern Washington Cascades (McAllister et al., 1993; McAllister, 1995; McAllister and Leonard, 1997). It has been estimated that this species has been lost from over 90 percent of its original range (Hayes, 1997). Three populations are known in Washington today, one in the south Puget Sound lowlands (Dempsey Creek) and two in the south-central Cascade Mountains (Trout Lake and Conboy Lake) (McAllister and Leonard, 1997). This species is highly aquatic. Key habitats in the Cedar River Municipal Watershed are marshy ponds, lakes, streams, and riparian areas as high as 3,000 m in parts of their range. The occurrence of this species in the Watershed is unknown.

Cascades Frog

The Cascades frog (*Rana cascadae*) is a federal species of concern. In Washington, the Cascades frog generally occurs above 800 m in the Olympic Mountains and in the Cascade Mountains both east and west of the Cascade Crest (silver fir, mountain hemlock, subalpine fir, grand fir, interior western hemlock, and alpine/parkland vegetation zones). Key habitats in the Cedar River Municipal Watershed are small ponds, lakes, slow-moving streams, and riparian areas. The species is present and is known to breed in the Watershed.

Western Pond Turtle

The western pond turtle (*Clemmys marmorata marmorata*) is a federal species of concern and a state endangered species in Washington. Records in Washington are clustered around the southeastern edge of Puget Sound and along a small portion of the Columbia River (Nussbaum et al., 1983; Washington Department of Wildlife (WDW), 1993). Populations are confirmed only in Klickitat and Skamania counties, with recent individual sightings documented in Pierce and King counties (WDW, 1993). Historical records also exist in Clark and Thurston counties (WDW, 1993). Pond turtles use marshes, sloughs, moderately deep ponds, and slow-moving portions of creeks and rivers (key habitats). The Cedar River Municipal Watershed does not have any habitat within the delineated elevation range of this species (City of Seattle, 1997).

Common Loon

The common loon (*Gavia immer*) is a state candidate species in Washington (WDFW, 1996). Common loons are known to breed at only a few locations in western Washington (Rodrick and Milner, 1991); they winter along the Pacific coast (WDNR, 1996). Declines in common loon populations have been attributed to the loss of nesting habitat (Ehrlich et al., 1988) and disturbance from motorboats. Key habitat for common loons is large, wooded lakes with dense populations of fish and the shoreline areas. Three mated pairs of common loons have been present on Chester Morse Lake/Masonry Pool during each nesting season for the last nine years (1989 to 1997) (City of Seattle, 1998).

Harlequin Duck

The harlequin duck (*Histrionicus histrionicus*) is a federal species of concern. This species breeds along fast-moving streams and rivers throughout the Cascade, Olympic, and Selkirk mountains in Washington (Bellrose, 1976; Brown, 1985). Harlequin ducks typically nest close to clear mountain streams with rocky substrates and rapids (HDWG, 1993). Bank vegetation near nest sites is highly variable, but the species is thought to show a preference for mature or old growth forests in the Pacific Northwest (HDWG, 1993). Key habitat for the harlequin duck in the Cedar River Municipal Watershed includes rivers and streams and associated bank vegetation and large woody debris (City of Seattle, 1998). The harlequin duck has been documented on the Cedar River and its major tributaries.

Great Blue Heron

The great blue heron (*Ardea herodias*) is a state monitor species in Washington. It is common in wetlands, mud flats, and agricultural areas at low to mid-elevations on both sides of the Cascade Crest (Smith et al., 1997). West of the Cascade Crest, great blue herons occur in all vegetation zones below the silver fir zone. These herons nest colonially in trees near water, and disperse to feeding areas which can include the marshy edges of ponds, lakes, and wetlands (Smith et al., 1997). Wetlands, lakes, ponds, riparian areas and wet meadows are key habitats for the species in the Cedar River Municipal Watershed. This species is present in the Watershed but its breeding status is undocumented.

Great Blue Heron

Osprey

The osprey (*Pandion haliaetus*) is a state monitor species in Washington. It is common along large water bodies (the ocean, lakes, and large rivers) in lower-elevation forested landscapes throughout Washington except for the Columbia Basin (Smith et al., 1997). Ospreys build large nests on dead trees or artificial structures, always near water (Smith et al., 1997). Lakes, conifer wetlands, and riparian areas are key habitats in the Cedar River Municipal Watershed. Several breeding pairs have been documented in recent years in the Watershed.

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) is a federal threatened species and a state threatened species in Washington (WDFW, 1996). Bald eagles occur year-round throughout Washington. Breeding habitat for the bald eagle typically includes mature and old growth forest within 1.6 km of water (FWS, 1986). Nest sites in western Washington are most commonly found in Douglas-fir and Sitka spruce trees. Roosting habitat for this species typically occurs in uneven-aged forest stands with some old growth characteristics close to a rich food source (Anthony et al., 1982). All lake, river and riparian habitats are considered key in the Cedar River Municipal Watershed. Bald eagles occur in the Watershed as transients and migrants.

Willow Flycatcher

The willow flycatcher (*Empidonax trailii*) is a federal species of concern. It is a common breeding species on both sides of the Cascades, on the Olympic Peninsula, in the southwestern part of the state, and in the northeastern and extreme southeastern parts of the state (Smith et al., 1997). Key habitats in the Cedar River Municipal Watershed are lower-elevation wetlands, shrub wetlands, meadow complexes, riparian areas, and clearcuts. The species is present and is known to breed in the Watershed.

Northern Water Shrew

The northern water shrew (*Sorex palustris*) is limited primarily by the presence of cold, clear water in small streams and ponds with abundant riparian cover (Johnson and Cassidy, 1997). This key habitat requirement limits the northern water shrew to steep, relatively high-elevation habitats that tend to produce aquatic habitats that meet these conditions. In Washington, this means primarily the mid to upper Cascade, the Olympic Mountains, and the Okanagan Highlands. The northern water shrew is present in the Cedar River Municipal Watershed.

Masked Shrew

The masked shrew (*Sorex cinereus*) occurs in a wide variety of habitats in Washington (Johnson and Cassidy, 1997), ranging from sea level near the Strait of Juan de Fuca to timberline in the Cascades. It avoids dry habitats such as the shrub-steppe zone of eastern Washington and is not found in the Puget Trough. It seems to prefer moist, forested habitats, regardless of elevation. Riparian habitats, especially within conifer forest, are considered key habitats for this species in the Cedar River Municipal Watershed. The occurrence of this species in the Cedar River Municipal Watershed is unknown.

Old-Growth Forest

Twenty-four wildlife species of concern are associated with the old-growth forest community. This community is dominated by bats (11 species) and birds (8 species). Other taxa includes four invertebrates and one additional mammal.

Johnson's (mistletoe) Hairstreak

Johnson's (mistletoe) hairstreak (*Mitoura johnsoni*) is a state candidate species in Washington (WDFW, 1996). This butterfly has larvae which are dependent upon species of dwarf mistletoe (*Arceuthobium* spp.) which occur primarily on western hemlock (Larsen et al., 1995). The species is known to occur in low elevation, late successional forests west of the Cascade Crest and on the Olympic Peninsula. Key habitats in the Cedar River Municipal Watershed are considered to be aquatic and riparian habitats and old growth forests. The occurrence of this species in the Watershed is unknown.

Mollusks

Three mollusks taxa are associated with old growth forests: the Oregon megomphix (*Megomphix hemphilli*), the Puget Oregonian (*Cryptomastix devia*), and the blue-gray taildropper (*Prophysaon coeruleum*). The habitat requirements of the Oregon megomphix, a state monitor species in Washington, are not well understood, but in Washington it has most commonly been found in moist, low elevation, relatively undisturbed forest west of the Cascades. They are usually found in moist microsites underneath rotting logs or in deep leaf litter or rocks (Burke, 1994). The Puget Oregonian, a state monitor species in Washington, has been reported from low to middle elevations riparian and old growth forests (Burke, 1994). The blue-gray taildropper has been found in low-elevation forested habitats on the westside of the Cascades in Washington (Burke, 1994). Key habitats for these three species in the Cedar River Municipal Watershed are considered to be aquatic and riparian habitats and old growth forests. The occurrence of these species in the Watershed is unknown.

Marbled Murrelet

The marbled murrelet (*Brachyramphus marmoratus*) is a federal threatened species and state threatened species in Washington (WDFW, 1996). Marbled murrelets have been detected up to 60 miles inland from marine waters (Burns et al., 1994); in Washington, this species is known to nest up to 39 miles inland of marine waters (Hamer, 1995). Late successional and old growth forests are the key habitats for marbled murrelets in the Cedar River Municipal Watershed. This species tends to nest in old growth or mature forests comprised of Douglas-fir, western hemlock, and western redcedar (among other species) (Ralph and Nelson, 1992). The FWS (USF&WS) has designated critical habitat for the marbled murrelet (FWS, 1996b). The FWS based the determination of critical habitat for this species on the Northwest Forest Plan. Designated critical habitat for this species includes LSRs, and other lands on which timber harvest is extremely or completely proscribed. In a 1992 survey in the Cedar River Municipal Watershed, WDFW detected marbled murrelet calls on two occasions in an area that was identified as having the greatest potential for providing nesting habitat for murrelets (City of Seattle, 1998). No additional surveys have been conducted to date.

Northern Spotted Owl

The northern spotted owl (*Strix occidentalis caurinus*) is a federal threatened species and a state endangered species in Washington (WDFW, 1996). Spotted owls occur throughout western Washington and the east slope of the Cascade Mountains (Thomas et al., 1990) at elevations below 1,540 m. Late successional and old growth forests are the spotted owl's key habitats in the Cedar River Municipal Watershed. The median home range for spotted owls in the western Cascade Mountains of Washington is 6,657 acres (the number of acres within a 1.8-mile radius "owl circle"). In 1991, the FWS designated a number of critical habitat units (CHUs) for protecting critical habitat for the northern spotted owl (FWS, 1992); the upper reaches of the Cedar River Municipal Watershed (22,845 acres) have been designated as part of CHU WA-33 (see Map 5). The WDNR also has a permanent rule for protection of the northern spotted owl (WAC 222-10-141). Under this rule, the state identified critical wildlife habitat for the spotted owl and also established 10 spotted owl special emphasis areas (SOSEAs) where critical wildlife habitat is designated around spotted owl site centers. Habitat goals have been established for each of these SOSEAs. Much of the upper Cedar River Municipal Watershed (48,877 acres) falls within the I-90 West SOSEA. This SOSEA contains lands designated for "demographic support" and other lands designated for "dispersal support." One breeding pair of northern spotted owls is known to occur in the Cedar River Municipal Watershed.

Northern Spotted Owl

Northern Goshawk

The northern goshawk (*Accipiter gentilis*) is a federal species of concern throughout its range in the U. S. and a state candidate species in Washington (WDFW, 1996). Northern goshawks occur throughout Washington, primarily in wet and dry conifer forest habitats (Wahl and Paulson, 1991). Late successional and old growth forests are the key habitats for the northern goshawk in the Cedar River Municipal Watershed. Foraging areas for this species comprise the largest portion of their home ranges, typically include a greater diversity of forest age classes and structural characteristics than nest areas, and tend to support abundant avian prey populations (Reynolds et al., 1992). The Draft Regional Protocol describes goshawk home ranges as approximately 6,000 acres in size with a core nest site of 430 acres (Marshall, 1992). At present, only one northern goshawk nesting territory has been documented within the Cedar River Municipal Watershed (City of Seattle, 1998).

Three-toed Woodpecker

The three-toed woodpecker (*Picoides tridactylus*) is a state monitor species in Washington. It occurs in high-elevation conifer forests in the Cascades, northeastern Washington, and southeastern Washington (Smith et al., 1997). They are generally found in closed-canopy dense forests, but will utilize open habitats and burns (Smith et al., 1997). Late successional and old growth conifer wetlands and conifer forests are the key habitats for this species in the Cedar River Municipal Watershed. Its occurrence in the Watershed is unknown.

Pileated Woodpecker

The pileated woodpecker (*Dryocopus pileatus*) is a state candidate species in Washington (WDFW, 1996). The species occurs from northern British Columbia south through Pacific states to central California. Pileated woodpeckers utilize late successional and old growth forests with substantial numbers of large snags and fallen trees; these are its key habitats in the Cedar River Municipal Watershed. The most suitable habitats are probably conifer stands with two or more canopy layers, the uppermost being 82 to 98 feet high (Bull, 1987). This woodpecker excavates large nest holes in snags or living trees with dead wood. The typical tree species for nest sites are Douglas-fir, grand fir, and western white pine, where available, west of the Cascade Crest (Lundquist and Mariani, 1991). This species is considered common in the Cedar River Municipal Watershed and is known to breed there.

Olive-sided Flycatcher

The olive-sided flycatcher (*Contopus borealis*) is a federal species of concern. The breeding range of the olive-sided flycatcher includes Alaska and extends south through the mountains of the Pacific Northwest. Based on data from North American breeding bird surveys, olive-sided flycatchers have apparently been in significant decline throughout much of the western U.S. and across its boreal North American range as well (DeSante and George, 1994; Dobkin, 1994). Key habitat for this species in the Cedar River Municipal Watershed is late successional and old growth forest, especially those forests with an abundance of snags (Ehrlich et al., 1988; Sharp, 1992). Olive-sided flycatchers may also use mixed woodlands near edges and clearings. This species is present in the Watershed.

Brown Creeper

The brown creeper (*Certhia americana*) is widely distributed in the Northern Hemisphere of both the New and Old Worlds. Brown creepers usually nest under a piece of loose bark on a tree (Ehrlich et al., 1988), but occasionally use a natural cavity or old woodpecker hole. Key habitat in the Cedar River Municipal Watershed includes late successional and old growth forest, including late seral conifer wetland forest (City of Seattle, 1998). This species is present and breeding in the Watershed.

Vaux's Swift

Vaux's swift (*Chaetura vauxi*) is a state candidate species in Washington (WDFW, 1996). Vaux's swifts nest in late successional coniferous forests (Bull and Collins, 1993). The species requires large, hollow snags or cavities in the broken tops of live trees for nesting and night roosting (WDNR, 1996). Hundreds of Vaux's swifts may use a single tree for roosting. Key habitats in the Cedar River Municipal Watershed are considered late successional and old growth forests. This species is present and is know to breed in the Watershed.

Fisher

The fisher (*Martes pennanti*) is a federal species of concern and a state candidate species in Washington (WDFW, 1996). This species is thought to occur in the Washington Cascades, Olympic Mountains, and in eastern Washington in portions of the Okanogan Highlands (Aubry and Houston, 1992). West of the Cascade Crest, trapping records of this species are from locations below 1,800 m (Aubry and Houston, 1992). Mature and old growth forests and forested riparian areas with at least 80 percent canopy coverage seem to provide the most suitable habitat for the fisher, although second growth and clearcuts may be used if sufficient cover is present (ODFW, 1992). Breeding habitat for fishers must contain an abundance of logs and snags used for maternity dens (Thomas, 1979). Riparian areas and lake shores located in and adjacent to forests, and late successional and old growth forests are key habitats in the Cedar River Municipal Watershed. The status of the fishers in the Watershed is unknown.

Marten

In Washington, marten (*Martes americana*) distribution is limited to mountain ranges that provide preferred coniferous forest habitat (Cascades, Olympics, Selkirks, Okanogan Highlands, and Blue Mountains) (Johnson and Cassidy, 1997). Martens are closely associated with late successional stands of mesic conifers, especially those with complex physical structure near the ground (Buskirk and Powell, 1994). Fallen trees and snags are apparently important because they provide resting spots and den sites, and habitat for prey (Johnson and Cassidy 1997). Martens may inhabit talus fields above treeline (Grinnell et al., 1937; Steeter and Braun, 1968), but are seldom or never found below the lower elevational limit of trees. Key habitats in the Cedar River Municipal Watershed include late successional and old growth forests, talus, and cave habitat. The occurrence of this species in the Watershed is unknown.

Canada Lynx

The lynx *(Lynx canadensis)* has been proposed for listing under the ESA by the USFWS, is a state threatened species in Washington, and is a Forest Service sensitive species. The lynx population in Washington is estimated to be between 96 and 191 individuals (WDW, 1993c). The lynx in Washington is found at elevations above 3,200 feet (Brittell et al., 1989), ranging from Canada into northeast and north-central Washington, to east of the Cascade Crest and through the Okanogan Highlands into northern Idaho (McCord and Cardoza, 1990; WDW, 1993c; Ruggiero et al., 1994). Recent research has placed this species reliably as far south as the Yakima Indian Reservation, the Blue Mountains, and the Oregon Cascades (personal communication, T. Thomas, Wildlife Biologist, USFWS, Olympia, WA, February 17, 1998). In recent years, lynx have been found on the west side of the Cascade Crest only in the northern part of the North Cascades (Ruggiero et al., 1994). This species occurs in very remote areas, using extensive tracts of dense forest that are interspersed with rock outcrops, bogs, and thickets (McCord and Cardoza, 1990; Ruggiero et al., 1994). Lynx use a mosaic of forest types from early successional to mature conifer and deciduous forest, as long as snowshoe hares are present (Ruggiero et al., 1994). No lynx observations have been documented in the Cedar River Watershed. Key lynx habitats in the Watershed are considered to be mature to old-growth forests, riparian areas, naturally-open habitats (meadows and persistent shrub communities), rock outcrops, and talus/felsenmeer – all at higher elevations.

Hoary Bat

The hoary bat (*Lasiurus cinereus*) occurs primarily as a summer resident in low- to mid-elevation wooded areas throughout Washington; it is not found in the driest areas of the Columbia Basin or at high elevation (Johnson and Cassidy, 1997). An Oregon study indicated that hoary bats prefer older conifer forests to younger forests, presumably because larger trees provide better roosts (Smith et al., 1997). Key habitats in the Cedar River Municipal Watershed are late successional and old growth forests, aquatic and riparian habitats, and caves. The occurrence of this species in the Watershed is unknown.

Big Brown Bat

The big brown bat (*Eptesicus fuscus*) occurs throughout Washington (Johnson and Cassidy, 1997). It is less common in alpine areas and perhaps less common in the driest parts of the Columbia Basin. The big brown bat often associates closely with humans. In summer they form colonies in attics and barns, beneath bridges, in rock crevices, and sometimes in quarry tunnels. They forage in a variety of situations, including over water, forest canopies, roads, clearings, and even urban areas (Johnson and Cassidy, 1997). In winter they hibernate singly or in small groups in buildings, caves, mines, tunnels, quarries, storm sewers, and other similar shelters. Key habitats in the Cedar River Municipal Watershed are late successional and old growth forests, aquatic and riparian habitats, and caves. The occurrence of this species in the Watershed is unknown.

Silver-haired Bat

The silver-haired bat (*Lasionycteris noctivagans*) occurs in suitable habitat throughout much of North America. It is found throughout forested areas of Washington from sea level probably into alpine parkland (Johnson and Cassidy, 1997). Silver-haired bats appear to be most abundant in old growth Douglas-fir/western hemlock forests, especially with high snag densities. Maternity roosts are almost exclusively in cavities and crevices in snags and trees, including cavities excavated by woodpeckers. Hibernacula and solitary roosts are found in buildings, rock crevices, caves, mines, in snags, and under bark (Christy and West, 1993). Kunz (1982) reported this species forages over water at ponds, streams, and other water bodies, usually near conifers and/or mixed deciduous forests. Key habitats in the Cedar River Municipal Watershed are late successional and old growth forests, aquatic and riparian habitats, and caves. The occurrence of this species in the Watershed is unknown.

Myotis spp.

Seven species of *Myotis* are associated with old growth forests. Key habitats for these in the Cedar River Municipal Watershed are late successional and old growth forests, aquatic and riparian habitats, caves, and cliffs. The occurrence of these species in the Cedar River Municipal Watershed is unknown. Individual species are described briefly in the following paragraphs.

The long-eared myotis (*Myotis evotis*) is a federal species of concern and a state monitor species in Washington (City of Seattle, 1998). The species occurs throughout Washington except in the driest parts of the Columbia Basin (Barbour and Davis, 1969; Johnson and Cassidy, 1997). Long-eared myotis can be found in a variety of habitats such as mature and immature conifer, alder/salmonberry, and arid grasslands (Nagorsen and Brigham, 1993). In the Pacific Northwest they apparently prefer coniferous forests for roosting and foraging sites (Perkins, 1983; Brown, 1985). They use buildings, pieces of loose bark attached to trees, caves, and rock fissures as roost sites (Nagorsen and Brigham, 1993). Roosting and breeding sites are often located in old growth forests. Maternity colonies of 12 to 30 individuals have been found in buildings and hollow trees (Maser et al., 1981).

The long-legged myotis (*Myotis volans*) is a federal species of concern and a state monitor species in Washington (City of Seattle, 1998). The species can be found throughout Washington except for the driest parts of the Columbia Basin (Johnson and Cassidy, 1997). This species occurs in a variety of habitats such as immature and mature conifer, alder, and arid range lands (Nagorsen and Brigham, 1993). Foraging habitat includes all seral stages, but there is a preference for young forest (Brown, 1985). Roosts and, probably, maternity colonies are located in buildings, crevices in rock cliffs, fissures in the ground, and under large pieces of tree bark (Nagorsen and Brigham, 1993). Maternity colonies typically contain several hundred individuals (Maser et al., 1981).

The fringed myotis (*Myotis thysanodes*) is a federal species of concern and a state monitor species in Washington (City of Seattle, 1998). It is restricted to drier areas in southeastern Washington (Barbour and Davis, 1969; Johnson and Cassidy, 1997). Habitat for the fringed myotis is highly variable, but it is typically found in deserts, arid grasslands, and dry, open forests (ODFW, 1992; Nagorsen and Brigham, 1993). The species has also been found in immature coniferous forests of the western Cascades (Madron, 1995). Fringed myotis roost in caves, mines, rock crevices, and buildings.

The California myotis (*Myotis californicus*) can be found in most forested habitats in Washington, and occasionally in the steppe zone of eastern Washington, especially along water courses (Johnson and Cassidy, 1997). It probably does not breed at high elevations (Johnson and Cassidy, 1997). Roosting habitat includes buildings, bridges, bark, rock crevices, caves, mines, and snags (Christy and West, 1993).

The little brown myotis (*Myotis lucifugus*) occurs in most forested habitats in Washington, as well as along riparian areas in the shrub-steppe zone of eastern Washington (Johnson and Cassidy, 1997). In Washington, the little brown myotis has been strongly associated with old growth conifer forests, where it is commonly seen foraging at forest edges, in meadows, and over water (Christy and West, 1993; Johnson and Cassidy, 1997). It is probably the most common bat in urban areas (Johnson and Cassidy, 1997).

The Yuma myotis (*Myotis yumanensis*) is a federal species of concern. It uses a variety of low to mid-elevation habitats—including coastal forests, Douglas-fir forests, and arid grasslands—as long as open water is nearby (Nagorsen and Brigham, 1993). Almost two-thirds of foraging time is spent over water (Brigham et al., 1992). Other foraging habitats include grass, shrub, and open sapling stages of hardwood and coniferous forests, as well as hardwood and coniferous wetlands (Brown, 1985). Breeding habitats (maternity colonies) include caves, mines, under bridges, and in buildings (Brown, 1985). This species is known to use snags in old growth forests for breeding sites (WDNR, 1996).

Keen's myotis (*Myotis keenii*) is a state monitor species in Washington (City of Seattle, 1998). In Washington, the species has only been found in low elevation forests in Puget Sound, the Olympic Peninsula, and in coastal British Columbia and Alaska (Johnson and Cassidy, 1997; Parker, 1996). Relatively little is known about the habitat requirements of Keen's myotis, but some data suggest that it prefers old growth coniferous forests over younger forests because of the structural diversity of the older forests (Parker, 1996). Keen's myotis has been known to roost in man-made structures. Difficulty in distinguishing Keen's myotis from long-eared myotis, which are sympatric over much of their range, has led to uncertainties about the range of Keen's myotis in Washington (Johnson and Cassidy, 1997).

Townsend's Western Big-eared Bat

The Townsend's western big-eared bat (*Plecotus townsendii townsendii*) is a federal species of concern and a state candidate species in Washington (WDFW, 1996). Townsend's western big-eared bats have been documented from sea level to 3,200 m (Pearson et al., 1952), but they occur chiefly at low to mid elevations (Johnson and Cassidy, 1997). This species can occur in nearly any forest type as long as suitable roost, nursery, and hibernaculum sites (caves, mines, buildings, and the undersides of bridges) are present; however, caves located within clearcuts are not suitable because the lack of vegetation can affect the microclimate (WDW, 1991). Late successional and old growth forests, aquatic and riparian habitats, and caves are considered to be the key habitats for this species in the Cedar River Municipal Watershed. The occurrence of this species in the Watershed is unknown.

Special Habitats

Eleven wildlife species of concern are associated with special habitats. This community is dominated by birds (7 species). Other taxa include one amphibian and three mammals.

Larch Mountain Salamander

The Larch Mountain salamander (*Plethodon larselli*) is a federal species of concern and a State Sensitive Species in Washington (WDFW, 1996). Until recently, the Larch Mountain salamander was thought to be endemic to a narrow region where the Columbia River cuts through the Cascade Mountains between Washington and Oregon (Herrington and Larson, 1987). In this area, the species is associated with steep, forested talus (Burns, 1964). Other populations have been documented in closed-canopy Douglas-fir stands with a rocky forest floor, lava tubes, and associated with piles of bark on the old growth forest floor. Key habitat for the Larch Mountain salamander in the

Cedar River Municipal Watershed is considered to be talus/felsenmeer adjacent to mature/old growth forest within the western hemlock/silver fir series. This occurrence of this species in the Watershed is unknown.

Band-tailed Pigeon

The band-tailed pigeon (*Columbia fasciata*) is a migratory, upland game bird in Washington that occurs west of the Cascade Crest (Rodrick and Milner, 1991). Concern for this species has been prompted by the population decline reflected in breeding bird surveys; populations in Washington have exhibited the greatest decline (Braun, 1994). During the nesting season, band-tails are more common in low-elevation forests (less than 1,000 feet elevation). This species is dependent on the availability of mineral resources (e.g., mineral springs) for producing crop milk for juveniles (Braun, 1994). Forested lands below 1,000 feet elevation in proximity to mineral springs are considered to be key habitat for this species in the Cedar River Municipal Watershed (City of Seattle, 1998). This species is present in the Watershed.

Rufous Hummingbird

The rufous hummingbird (*Selasphorus rufus*) occurs from southeastern Alaska south through Washington and Oregon, to northwestern California and southern Idaho. According to breeding bird surveys, rufous hummingbird population numbers declined over a 10-year period in Washington (Andelman and Stock, 1994). Rufous hummingbirds forage over a great variety of habitats, mainly where flowers are available, from valley bottoms to meadows above timberline. It nests in a variety of trees, brushes, and vines, favoring low, sloping branches of conifers. Key habitats in the Cedar River Municipal Watershed are meadow complexes, riparian habitats, and additional shrub communities. This species is common in the Watershed.

Golden Eagle

The golden eagle (*Aquila chrysaetos*) is a state candidate species in Washington (WDFW, 1996). Golden eagles are most common in the open dry forests of the east Cascades, northeastern Washington, and southeastern Washington (Smith et al., 1997). West of the Cascade Crest, golden eagles are found in the rain shadow area of major volcanoes, at high elevations in alpine parkland, and in clearcuts at mid elevations (Smith et al., 1997). Golden eagles nest on large, rocky cliffs in areas where small mammal prey is abundant (Smith et al., 1997). Cliffs, meadow complexes and shrub communities are considered the key habitats in the Cedar River Municipal Watershed. The occurrence of this species in the Watershed is unknown.

Merlin

The merlin (*Falco columbarius*) is a state candidate species in Washington (WDFW, 1996). Two distinct subspecies of merlin occur in Washington

(Smith et al., 1997), with the taiga merlin (*F.c. columbarius*) the subspecies most likely to occur in the Cedar River Municipal Watershed. It is likely that the taiga merlins occur as rare breeders in high-elevation Cascades forests that mimic boreal conditions (Smith et al., 1997). Key habitats in the Cedar River Municipal Watershed are open meadows, shrub communities, and cliffs. This species is present in the Watershed.

Peregrine Falcon

The peregrine falcon (*Falco peregrinus*) is both a federal endangered species and a state endangered species in Washington (WDFW, 1996). Peregrine falcons occur year-round in Washington, as either nesting or migratory individuals. Potential nesting and roosting habitat for this species usually includes cliffs or high escarpments that dominate the nearby landscape, although office buildings, bridges, and river cutbanks have been used for nesting as well (PFRT, 1982; Craig, 1986). Foraging habitat for peregrines includes open areas with an abundance of potential prey, such as marshes, lakes, river bottoms, croplands, and meadows (Porter and White, 1973). Cliffs are the key habitat for peregrines in the Cedar River Municipal Watershed. The occurrence of this species in the Watershed is unknown.

Black Swift

The black swift (*Cypseloides niger*) is a state monitor species in Washington. It occurs in mid- to late seral mixed and conifer forests at moderate elevations in the Cascades north of Mt. Rainier (Smith et al., 1997). Few nests have been documented in Washington, but they have been found on steep cliffs and behind waterfalls (Smith et al., 1997). Riparian and stream habitats and cliffs are key habitats in the Cedar River Municipal Watershed. The species is present in the Watershed.

Western Bluebird

The western bluebird (*Sialia mexicana*) is a state candidate species in Washington. It is locally common in open conifer forests, farmlands, and steppe habitats on the east side of the Cascades, in northeastern Washington, and in the extreme southeastern part of the state (Smith et al., 1997). In western Washington, the species has undergone a drastic and well-documented decline during this century, which has been attributed to a combination of competition with house sparrows and European starlings, widespread removal of snags used as nest trees (they are cavity nesters), and overall reductions in prey populations (Smith et al., 1997). Wetland areas and meadows are key habitats in the Cedar River Municipal Watershed. This species is considered incidental in the Watershed.

Grizzly Bear

The grizzly bear (*Ursus arctos*) is a federal threatened species and state endangered species in Washington (WDFW, 1996). Grizzly bears occurred historically throughout most of central and western North America (FWS, 1982). In 1997, approximately 5 to 10 grizzly bears were believed to reside in the North Cascades (personal communication, J. Almack, WDFW, Sedro Woolley, Washington, November 18, 1997) with most of these sightings occurring north of the Skykomish Ranger District. The grizzly bear recovery plan identified the North Cascades grizzly bear ecosystem as one of six possible recovery areas for this species (FWS, 1993). The grizzly bear is a very wide-ranging species that typically uses many vegetation types to fulfill its life requisites. Areas with low human activity are considered to be more suitable for this species (IGBC 1994). All naturally nonforested habitats, meadows, riparian areas, and late successional/old growth forests are key habitats in the Cedar River Municipal Watershed. The occurrence of this species in the Watershed is unknown.

Gray Wolf

The gray wolf (*Canis lupus*) is a federal endangered species and a state endangered species in Washington (WDFW, 1996). There have been two confirmed sightings of wolf family groups in Washington in the past 10 years, in North Cascades National Park and the Okanogan area; three other sightings appear to be reliable, but unconfirmed (Personal communication, J. Almack, WDFW, Sedro Woolley, Washington, November 18, 1997). The gray wolf is a very wide-ranging species that uses almost any natural habitat (Laufer and Jenkins, 1989), including forest lands and natural openings (e.g., alpine meadows, shrublands, and marshes), as long as the level of human activity is low, and an adequate ungulate prey base is available (Laufer and Jenkins, 1989). Suitable denning and rendezvous habitat for the gray wolf is defined as broad valley bottoms away from human disturbance, usually at high elevations (Mech et al., 1988). All naturally nonforested habitats, meadows, riparian areas, and late successional/old growth forests are key habitats in the Cedar River Municipal Watershed. The occurrence of this species in the Watershed is unknown.

Wolverine

The wolverine (*Gulo gulo*) is a federal species of concern and a state monitor species in Washington. Wolverines are wide-ranging animals that inhabit a variety of habitats, but are generally found in remote, montane forest areas (Butts, 1992). Wolverines avoid clearcuts, although they travel through them if necessary. Den sites are usually located in areas with an abundance of fallen logs and deep snow (Hatler, 1989). Wolverines will use managed lands adjacent to a refuge such as a large wilderness area or national park. All naturally nonforested habitats (especially talus), meadows, riparian areas, and late successional/old growth forests are key habitats in the Cedar River

Municipal Watershed. The occurrence of this species in the Watershed is unknown.

3.5.3 Habitat Fragmentation and Connectivity

Within the Cedar River Municipal Watershed

The lower and upper municipal watersheds exhibit two distinctly different landscape patterns relative to forest habitat fragmentation (Map 4). The landscape of the lower municipal watershed is an essentially continuous canopy of second growth coniferous forest (ranging from 51 to 90 years of age) which has regenerated since the original harvest of nearly all native forest stands in the area. A few recent clearcuts interrupt the canopy in scattered locations. The landscape of the upper municipal watershed, by contrast, resembles more of a patchwork quilt, with patches of old growth forest interspersed with large patches of mid seral and early seral forest (Resource Map 4).

There are at least 50 separate patches of remaining old growth forest in the Cedar River Municipal Watershed (Resource Map 4). The overwhelming majority of old growth acreage is in the upper municipal watershed, and most of that is above 2,500 feet elevation and east of the confluence of the Cedar River with Chester Morse Lake. Most old growth in the upper municipal watershed is in six relatively large, high-elevation blocks in the eastern third of the watershed: (1) surrounding Mt. Baldy, Abiel Peak, and Tinkham Peak along the northeastern boundary; (2) immediately west of Meadow Mountain at the eastern boundary; (3) the area surrounding Goat Mountain on the southeastern boundary; (4) the area surrounding Findley Lake; (5) the upper Rex River basin; and (6) south and southeast of Mt. Kent. All six of these old growth blocks have some internal natural fragmentation caused by rock outcrops, talus/felsenmeer, or nonforested uplands, and all six are surrounded by early seral or young mid seral forests.

An analysis of interior old growth forest patches was also conducted. Interior old growth forest is considered that part of the forest where edge effects no longer influence microclimate and species composition. For purposes of analysis, edge effects were assumed to extend 400 feet into the forest from any boundary, whether natural (e.g., a rock outcrop or talus slopes) or human-created (e.g., a clearcut or early seral forest) (Morrison et al., 1992). Thus, a 400-foot-wide band was removed from the perimeter of all old growth forest stands in order to calculate the number and area of interior old growth forest patches. Subsequent calculations yielded a total of 171 interior old growth forest patches remaining in the Cedar River Municipal Watershed, ranging from less than one-tenth acre to 1,429 acres. (It should be noted here that many of these interior old growth patches are connected to one another by old growth exhibiting edge effects). The largest remaining patches of interior old growth are 1,429 acres west of Meadow Mountain, 677 acres along Bear Creek southwest of Mt. Baldy, 525 acres south of Tinkham Peak, and 393 acres south of Findley Lake. These are all in the upper municipal watershed.

Regional

Connectivity of forest habitats is critical to the movement, dispersal, and gene flow of species across the landscape. Habitat can become isolated through large-scale removal of habitat (e.g., timber harvest), construction of long, linear projects (e.g., roads and powerlines) that bisect contiguous patches of forest, and encroachment of human activity. Habitat connectivity is an important issue for (1) old growth-associated species (e.g., northern spotted owl), especially those with low dispersal capability (e.g., shrew-mole, *Neurotrichus gibbsii*); (2) species with key habitats that are naturally fragmented or in short supply (e.g., Larch Mountain salamander); (3) species that occur in naturally low densities, tend to disperse long distances from natal areas, and have specific habitat needs (e.g., fisher); (4) seasonally migratory species (e.g., elk); and (5) species that require different habitats for feeding and nesting (e.g., marbled murrelet). Wide-ranging species in particular suffer from the effects of human encroachment associated with the fragmented forest. The grizzly bear, wolverine, fisher, marten, and gray wolf are wide-ranging species that require areas away from high levels of human activity. Lack of such security habitat, in particular, inhibits the recovery of the grizzly bear and gray wolf.

On a regional level, the Cedar River Municipal Watershed is an important link in the north-south and east-west connectivity of wildlife habitats in the central Washington Cascades. North to south, the Cedar River Municipal Watershed is situated between the South Fork of the Snoqualmie River Watershed and the Green River Watershed. The CHU in the upper municipal watershed connects a Forest Service LSR centered around Humpback Mountain to the northeast with the Smay Creek and Kelly Butte areas of the Green River Watershed to the south. East to west, the Cedar River Municipal Watershed helps connect the Cascade crest and lands east of the crest (Snoqualmie Pass Adaptive Management Area) with forested areas to the northwest (e.g., Squawk Mountain State Park, Tiger Mountain State Forest, Rattlesnake Mountain DNR lands) which are themselves connected with other protected areas extending nearly to Lake Washington (e.g., Mountain to the Sound Greenway). As such, the Cedar River Municipal Watershed is probably the major east-west corridor for wildlife in the central Washington Cascades.

3.5.4 Summary

Wildlife habitats, key wildlife communities (aquatic and riparian, old growth forest, and special habitats) and wildlife species of concern in the Cedar River Municipal Watershed were discussed above to the provide the background necessary to assess the environmental consequences of the proposed alternatives on these resources. The role of the Cedar River Municipal

Watershed with regards to regional habitat connectivity and fragmentation was also described. In Section 4.5, the environmental consequences of the alternatives on wildlife habitats and on certain key species (species with individual conservation strategies) will be discussed in detail. In addition, the function of the Cedar River Municipal Watershed with regards to habitat connectivity and fragmentation on a regional scale will also be described in relationship to the alternatives.

Quality and quantity of wildlife habitat expected to be present at Year 0, at Year 20, and at Year 50 of the HCP in each of the five alternatives are based on the results of growth projection modeling of forest seral stages conducted by Seattle Public Utilities, Watershed Management Division. Expected changes in habitat quality under each alternative are based on a qualitative evaluation of management actions to enhance habitat proposed under each alternative. These management actions include, but are not necessarily limited to, restoration thinning, ecological thinning, precommercial thinning, commercial thinning, restoration planting, and various aquatic and riparian restoration projects. Details of these actions are presented in Chapter 2.

3.6 Cultural Resources

3.6.1 Introduction

Cultural resources include historic and hunter-fisher-gatherer archaeological sites, standing structures, and traditional cultural properties. Traditional cultural properties are places associated with the beliefs, customs, and practices of a living community that have been passed down orally or through practice (Parker and King, 1992). Within the Cedar River Municipal Watershed, the affected groups that may have traditional cultural use are the recognized tribes, including the Muckleshoot Tribe, Snoqualmie Tribe, Tulalip Tribes, Suquamish Tribe, the Yakama Indian Nation, the Colville Confederated Tribes (heir to Wenatchee interests), and the Duwamish Tribe, which is not recognized by the Federal government.

Cultural resources have been addressed by a series of federal laws, including the National Historic Preservation Act (NHPA) and subsequent amendments. Section 106 of the NHPA requires that a federally assisted or federally permitted undertaking shall take into account the effect of the undertaking on any historic district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places. National Register Bulletin 38, *Guidelines for Evaluating and Documenting Traditional Cultural Properties,* elaborates on the definition, identification, and evaluation of traditional cultural properties (Parker and King, 1992). Under NEPA, agencies have broad responsibilities to assess the impacts of their activities on the environment, including historic properties. However, NEPA requires the consideration of a variety of impacts including cumulative impacts which is not required by the NHPA. SEPA also requires that the effects of undertakings on significant cultural resources be considered.

Cultural resources in the Watershed are abundant and varied. Much of the Watershed has been inventoried for cultural resources although certain high probability areas have not been examined. The cultural resource base in the Watershed is protected by federal laws and City policies.

3.6.2 Affected Environment

Hunter-fisher-gatherer land use and the history of the Watershed are especially well-preserved in the Watershed due to the documentation and preservation of records of property as the City acquired the Watersheds and the restriction of public access since the early twentieth century. Cultural resources identified within the last 20 years have provided information on the rich and dynamic legacy of the Indian people who camped, fished, hunted, gathered berries, traded with different groups, and used the travel routes through the Watershed for over 9,000 years. The history of Euroamerican settlement, mining, railroad, hydroelectric, and municipal water supply development in the Watershed is documented in the standing structures and archaeological deposits preserved in the Watershed.

3.6.3 Previous Cultural Resources Studies

Thirty-eight studies have been published on the cultural resources of the Watershed (Table 1 in Appendix A). Six studies are overviews of the Watershed that primarily address the historic resources documented in the archival record. All overviews proposed high probability areas for hunter-fisher-gatherer and historic period resources based on environmental characteristics or information in the archival record. Twenty-one studies in the Watershed had an archaeological field component, but most were not systematic and most were concentrated in the Masonry Dam and Chester Morse Lake vicinity. Archaeological testing, surface collection, and mitigation of several sites on Chester Morse Lake followed identification of the Chester Morse Archaeological District and the determination of the District's eligibility for inclusion in the National Register of Historic Places.

Studies associated with the Morse Pumping Plant were undertaken in the, 1990s. Landsburg has also been the focal point for five archaeological surveys by the Seattle Water Department/Seattle Public Utilities, Burlington Northern Railroad, and the Washington State Department of Fish and Wildlife. Land ownership in the Watershed was shared by the USFS, which conducted an American Indian religious use study and cultural resource overview of the Mt. Baker-Snoqualmie National Forest, including the Watershed (Blukis Onat and Hollenbeck, 1981; Hollenbeck, 1987). The USFS also identified sites through a timber sale survey (Peter, 1978) and a multiple parcel land exchange (Wilke, 1980).

Cultural Resources Inventory

Forestry technicians, archaeologists, historians, and architectural historians have identified a diverse array of hunter-gatherer archaeological sites, historic archaeological sites, historic structures, and a traditional cultural use site during cultural resource investigations in the Watershed. About 10 percent of the high probability areas have been inventoried for archaeological resources and all standing structures in the Watershed have been inventoried.

Hunter-Fisher-Gatherer Resources

The most impressive array of hunter-gatherer resources in the Watershed is the suite of sites identified on Chester Morse Lake (Table 2 in Appendix A). These sites chronicle land use in a foothill lake setting over 9,000 years and document a trade route between Indian groups in eastern and western Washington. Evidence of land use on the lake from the past 700 years is scant, but there is ample evidence of hunting by highly mobile task groups for the previous seven millennia (Samuels, 1993). The lake is above the blockage for anadromous fish but some archaeological data indicate fishing for resident freshwater fish in the lake. Six of the nine hunter-gatherer sites on Chester Morse Lake are included in the Chester Morse Archaeological District. Other hunter-fisher-gatherer archaeological sites in the Watershed consist of stripped cedars, scarred from bark removal for textile and basketmaking, and lithic scatters. A rockshelter site has also been identified as well as sections of historic trails which probably have aboriginal antecedents, especially the Cedar River Pack Trail. Vast areas of the Watershed have not been inventoried, suggesting that unknown hunter-fisher-gatherer resources exist in the Watershed.

Historic Archaeological Resources

The Watershed also has a wealth of historic archaeological resources that relate to exploration, military expeditions, settlement, mining, logging, railroad construction, and the municipal history of the Watershed, reflecting the range of historic activities that have led to development throughout western Washington (Table 2 in Appendix A). Two historic sites, the Damburat Homestead and the Cedar Lake Logging Site, are within the boundaries of the Chester Morse Lake Archaeological District. However, the remains of homesteads, cabins, and even towns, such as Taylor, Moncton, and Sherwood, are also in the upper and lower reaches of the Watershed. Two towns, Hemlock and Japanese Camp, were inhabited by Japanese drawn to the logging industry. Historic roads and trails criss-cross the Watershed, some leading to the remains of mines, shafts, and shaft tunnels. The archaeological evidence of logging camps is ample, and also includes a Japanese logging camp.

The archival database documenting historic period land use in the Watershed is unusually detailed. Through the examination of territorial survey maps, condemnation records and maps, and photographs and interviews with former residents of the Watershed, a list of historic locations has been compiled by watershed cultural resources personnel. Some locations have been field-checked by forestry technicians, while others have not. Table 3 in Appendix A is a list of historic locations culled from archival data and a designation regarding the need for field assessment.

Clay sewer pipe stacked at Taylor town site, 1914

Historic Structures

A few historic structures still stand in the Watershed, although most were razed after condemnation. Historic structures in the Watershed primarily relate to the development of the watershed for hydroelectric power and water management although a railroad structure is standing (Table 4 in Appendix A). The Cedar Falls Power Plant Historic District was identified for the Masonry Dam Improvement Project and includes the Masonry Dam, Crib Dam, Penstock, Power Plant, and related structures. These structures were included in the Cedar Falls Historic District and placed on the National Register of Historic Places.

Traditional Cultural Properties

One traditional cultural use site has been identified, Lookout Mountain, which was reported in the *Inventory of Native American Religious Use Practices, Localities, and Resources, Study Area on the Mt. Baker-Snoqualmie National Forest, Washington State* (Blukis Onat and Hollenbeck, 1981). Two studies have been conducted which address traditional cultural use in the Watershed, including Blukis Onat and Hollenbeck (1981) and the report, *American Indian Religious Use in the Cedar River Watershed* (Larson, 1987). However, both studies predate National Register Bulletin 38, *Guidelines for Evaluating and Documenting Traditional Cultural Properties* (Parker and King, 1992) and may require additional work to meet the standards set by Bulletin 38. Consultation between the affected tribes and the Watershed also suggests that the issue of traditional cultural properties may need to be revisited to ensure tribal access to places and natural resources with cultural associations in the Watershed.

Other Cultural Resources Data

The Watershed has an artifact collection derived from data recovery of the hunter-fisher-gatherer archaeological sites on Chester Morse Lake and Rattlesnake Lake, testing efforts of historic archaeological sites in the Watershed, and isolated finds collected by forestry technicians and other watershed personnel throughout the history of the Watershed. The Watershed's archival inventory is also quite extensive and was recently documented (Stump and Hicks, 1993). Cultural resources archival data include condemnation records, maps, and photographs; cultural resources worksheets; contractor's cultural resources reports; historical notes, maps, photographs, and letters; and tape recordings of interviews. The Cedar River Watershed Education Center, to be constructed at Rattlesnake Lake, will house the artifact collection and the archives using federal standards for curation.

3.6.4 Cultural Resources Evaluation

Most formal evaluation efforts in the Watershed were undertaken as part of the Masonry Dam Improvement Project. The Chester Morse Archaeological District, a suite of hunter-fisher-gatherer sites, and the Cedar Falls Power Plant Historic District were determined eligible for inclusion in the National Register of Historic Places. More recently, the Landsburg Waterworks was determined eligible for inclusion in the National Register by Lentz (1997). Tables 2,3, and 4 in Appendix A present the evaluation status for the archaeological sites and historic structures in the Watershed. The traditional cultural site is not included in the tables and has not been evaluated for listing in the National Register of Historic Places.

Although most of the Watershed's cultural resources have been evaluated against National Register criteria, watershed cultural resources personnel have also developed criteria for archaeological sites based on their interpretive and educational value. Thus, even if a cultural resource does not meet National Register criteria, the resource still may have value to the Watershed's interpretive and educational staff and may be protected.

Watershed Cultural Resources Management

The Watershed's cultural resources staff is in an ongoing process for managing the Watershed's cultural resources. All cultural resources except the Watershed's single identified traditional cultural site are plotted on the Watershed's GIS maps. Each archaeological site, historic structure, and location with recorded historic activities has a management recommendation which reflects the required action if the site or location will be affected by a proposed undertaking. The management recommendations are included in Tables 2 and 3 in Appendix A. In addition, the Watershed is developing a Cultural Resources Management Plan which will include guidelines for daily management of the Watershed's cultural resources.

3.6.5 Summary

The Watershed's rich cultural resource base could be affected depending on whether their locations are in or out of the Reserve, and their potential to be affected by reservoir operations, other operations, and timber harvest practices. However, the cultural resources are protected by federal laws, City policies, and management practices. Effects are discussed in Section 4.6. In this section, the distribution of recorded archaeological sites, locations of possible historic resources, and environmental zones with a high probability for hunter-fisher-gatherer cultural resources will be used to compare and analyze the alternatives.

Table 3.6-1. Cultural Resources Studies Conducted in the Cedar River Watershed

Area[1/]	Type of Study	Date	Author(s)	Affiliation[2/]	Project	Cultural Resources Noted/Recorded/Evaluated	Documentation
CML	Field Reconnaissance	1978	Lewarch and Larson	OPA	Cedar Falls Improvement Project	45KI25, 45KI26H, 45KI27, 45KI28H, 45KI29, 45KI30, 45KI31, 45KI32	An Archaeological Assessment of Chester Morse Lake and Masonry Dam Pool. OPA Reconnaissance Report No. 15.
UPR	Field Reconnaissance	1978	Peter	USFS	USFS Hi Ho	CRW No. 033	CR Inventory #CR05-05-02
CRW (TRW)	Overview	1979	Lewarch	OPA	Cedar Falls Improvement Project	45KI25, 45KI26H, 45KI27, 45KI28H, 45KI29, 45KI30, 45KI31, 45KI32; tables of mining, logging camps, homesteads, and other historic sites	A Summary Cultural Resources Overview of the Cedar and Tolt River Watersheds. OPA Reconnaissance Report No. 24.
UPR	Field Reconnaissance	1980	Wilke	Geo Recon International	USFS Land Exchange	CRW Nos. 097, 077, 009, 033, 012	Cultural Resource Assessment of Cedar River Exchange Lands Contract No. 53-05M6-0-0079N.
CML	Field Reconnaissance	1981	Blukis Onat	BOAS	Cedar Falls Improvement Project	45KI25, 45KI32, 45KI288; CRW No.100	Report of Archaeological Field Reconnaissance Dam Safety Phase of the Cedar Falls Headworks Improvement Project, City of Seattle, City Light Dept.
CRW	Overview	1981	Blukis-Onat and Hollenbeck, editors	ICR	Mt. Baker-Snoqualmie National Forest Overview	Lookout Mountain TCP	Inventory of Native American Religious Use Practices, Localities, and Resources. Study Area on the Mt. Baker-Snoqualmie National Forest, Washington State.
LWR	Field Reconnaissance	1981	Holley et al./ Archaeological Research Serv.	ARS	Cedar R. Salmon Hatchery; Landsburg Dam-WA State Dept. of Fisheries	CRW No. 103	Cultural Resource Survey for Cedar River Salmon Hatchery, Landsburg Dam, Washington.
CML	Field Reconnaissance	1982	Kennedy	OPA	Cedar Falls Improvement Project	None	Archaeological Investigations for Proposed Wells, Cedar Falls-Morse Lake Hydrologic Study.
CML	Field Reconnaissance	1984	Cavazos	OPA	Cedar Falls Improvement Project	None	Cultural Resource Assessment of Borrow Pit Test Trenches for the Cedar Falls-Morse Lake Project, King County, Washington.
CML	Field Reconnaissance	1984a	Larson	OPA	Cedar Falls Improvement Project	None	Cultural Resource Assessment of Geotechnical Test Drillholes for the Cedar Falls-Morse Lake Project.
CML	Field Reconnaissance	1984b	Larson	OPA	Cedar Falls Improvement Project	None	Cultural Resource Assessment of Proposed Borrow Pit Locations for the Cedar Falls-Morse Lake Project.
CML	Overview	1984c	Larson	OPA	Cedar Falls Improvement Project	None	Report on Historical and Archaeological Resources of Cedar Falls-Morse Lake Project.
CML	Field Reconnaissance	1985a	Larson	OPA	Cedar Falls Improvement Project	None	Cultural Resource Assessment of Soils Evaluation Test Pits for the Cedar Falls-Morse Lake Project.
CML	Field Reconnaissance; Evaluation	1985b	Larson	OPA	Cedar Falls Improvement Project	45KI286H, 45KI287H, 45KI288H, 45KI289H	Cultural Resource Assessment of Proposed Construction Staging Areas for the Cedar Falls Improvement Project.
CML	Mitigation	1986	Harvey and Shoemaker	C&D	Cedar Falls Improvement Project	Cedar Falls Hydroelectric Works - CRW No. 100	Historic American Engineering Record Report: CF Hydroelectric Works HAER #WA-15.
CML	Evaluation	1986	Jermann and Kielusiak	URS Corp.	Cedar Falls Improvement Project	CMAD, 45KI26H, 45KI28H, 45KI286H, 45KI287H, 45KI288H, 45KI289H; CRW No. 100	Preliminary Case Report-Cedar Falls Improvement Project.
CML	Evaluation	1986	Jermann	URS Corp.	Cedar Falls Improvement Project	45KI25, 45KI26H, 45KI27, 45KI28H, 45KI29, 45KI30, 45KI31, 45KI32, 45KI286H, 45KI287H, 45KI288H, 45KI289H,	US Army Corps of Engineers Determination of No Adverse Effect-Cedar Falls Improvement Project

Table 3.6-1. Cultural Resources Studies Conducted in the Cedar River Watershed

Area[1/]	Type of Study	Date	Author(s)	Affiliation[2/]	Project	Cultural Resources Noted/Recorded/Evaluated	Documentation
LWR	Assessment	1986a	Robinson	AHS	BNRR ROW: Trude-Ravensdale	45KI290	A Cultural Resources Survey of SR 405 Trude to Ravensdale Connection. AHS Short Report #DOT86-15.
LWR	Assessment	1986b	Robinson	AHS	BN Renton-Trude Abandonment	RR bridges	A Cultural Resources Investigation of Burlington Northern RR's Line from Renton to Trude. AHS Short Report #DOT 86-19.
CML	Mitigation	1986	Schalk and Larson	OPA	Cedar Falls Improvement Project	CMAD, 45KI26H, 45KI28H, 45KI286H, 45KI287H, 45KI288H, 45KI289H; CRW No. 100	Final Cedar Falls Improvement Project Cultural Resources Mitigation Plan.
CRW	Overview; Field Reconnaissance	1987a	Getz	SWD	Graduate Research/SWD Grant	Most known	Cedar River Watershed Cultural Resource Study.
LWR	Evaluation	1987b	Getz	SWD	Taylor Townsite NRHP Nomination	CRW No. 3	Taylor Townsite, Draft Nomination to the NRHP.
CRW	Overview	1987	Hollenbeck	USFS	National Forest Act Compliance	CRW Nos. 166 (NB 146), 035 (CR06-05-05-14), 129, 165, 167, 162, 101; CMAD	A Cultural Resources Overview: Prehistory, Ethnography, and History-Mt.Baker-Snoqualmie National Forest.
CRW	Overview	1987	Larson	BOAS	Cedar River Watershed Secondary Use Analysis	None	American Indian Religious Use in the Cedar River Watershed. BOAS Research Report No. 8701.
CML	Evaluation	1987	Kennedy (In Schalk and Taylor 1992)	BOAS	Cedar Falls Improvement Project	45KI298, 45KI299, 45KI300	Cultural Resource Reconnaissance of the Chester Morse Lake Probable Maximum Flood Pool 1555-1570 ft. Elevation.
CML	Evaluation	1992	Schalk and Taylor	CNA	Cedar Falls Improvement Project	45KI25, 45KI29, 45KI30, 45KI31, 45KI32, 45KI298, 45KI299, 45KI300	The Archaeology of Chester Morse Lake: The Investigations for the Cedar Falls Improvement Project.
CRW	Field Reconnaissance; Evaluation	1990	Larson and Lewarch	LAAS	Sockeye Spawning Channel/Fish Hatchery	CRW Nos. 103, 201, 105	Cultural Resource Assessment of Cedar River Watershed Sockeye Spawning Channel/Fish Hatchery King County, Washington. LAAS Technical Report 90-4.
CML	Assessment	1991	Hess and Stump	BOAS	Temporary Pumping Plant EIS	CMAD	Morse Lake Temporary Pumping Plant No. 2: Draft EIS (section)
CML	Mitigation	1993	Forrest and Larson	LAAS	CMAD Monitoring	45KI25, 45KI29, 45KI30, 45KI31, 45KI32, 45KI300	Cultural Resources Monitoring, Chester Morse Lake, Preliminary Report. LAAS Technical Report #93-6.
CML	Mitigation	1993	Samuels, ed.	CNA	Cedar Falls Improvement Project	45KI25, 45KI27, 45KI29, 45KI30, 45KI31, 45KI32, 45KI298, 45KI299, 45KI300	The Archaeology of Chester Morse Lake: Long-term Human Utilization of the Foothills in the Washington Cascade Range. Project Report No. 21.
CRW	Archival Inventory	1993	Stump and Hicks	BOAS	Watershed Resource Inventory: GIS Phase	Most known	Natural and Cultural Resource Inventory for the Cedar River Watershed.
RSL	Field Reconnaissance; Evaluation	1994	Hicks et al.	BOAS	Morse Pumping Plant	45KI434; State No. 17-43 Edgewick Lumber Mill	Morse Pump Plant Cultural Resources Mitigation: Rattlesnake Lake and Boxley Creek. BOAS Research Report No. 9214-1.
CML	Mitigation	1994	Grant and Larson	LAAS	CMAD Monitoring	45KI25, 45KI29, 45KI30, 45KI31, 45KI32, 45KI300	Cultural Resource Monitoring Effort of Chester Mores Lake Archaeological District, 1993 Season.
RSL	Field Reconnaissance; Evaluation	1995	Hicks	BOAS	Morse Pumping Plant	CRW No. 201	Morse Pump Plant CR Mitigation, Task A.9 (Railroad Camp)

Table 3.6-1. Cultural Resources Studies Conducted in the Cedar River Watershed

Area[1/]	Type of Study	Date	Author(s)	Affiliation[2/]	Project	Cultural Resources Noted/Recorded/Evaluated	Documentation
LWR	Archival Research; Oral History	1995	Woodman and Gilbert	SWD	Barneston Japanese Community	Barneston	Barneston's Japanese Community
LWR	Archival Research; Oral History	1996	Brown and Schroeder	SWD	Barneston Japanese Community	Barneston	Barneston, Washington: An Investigation of Place and Community Through Photographs, Maps, and Oral Histories
LWR	Evaluation	1997	Lentz	CRC	Landsburg Master Plan	Landsburg Headquarters	Historical Review and Documentation, Seattle Public Utilities Landsburg Master Plan
LWR	Field Reconnaissance; Evaluation	1997	Robbins et al.	LAAS	Landsburg Master Plan	Portions of Landsburg Headworks ca. 1900	Landsburg Master Plan, King County, Washington Cultural Resource Assessment. LAAS Technical Report #97-10.

1/ CML-Chester Morse Lake
CRW-Cedar River Watershed
RSL-Rattlesnake Lake
UPR-Upper Cedar River Watershed above Chester Morse Lake
LWR-Lower Cedar River Watershed below Chester Morse Lake
NRHP-National Register of Historic Places

2/ AHS-Archaeological and Historical Services, Eastern Washington University
ARS-Archaeological Research Services
BOAS-Blukis Onat Applied Sciences
C&D-Chronicles & Design, Inc.
CNA-Center for Northwest Anthropology, Washington State University
CRC-Cultural Resource Consulting, Incorporated
ICR-Institute of Cooperative Research, Inc.
LAAS-Larson Anthropological/Archaeological Services
OPA-Office of Public Archaeology, University of Washington
SWD-Seattle Water Department
USFS-United States Forest Service

Table 3.6-2. Hunter-Fisher-Gatherer and Historic Archaeological Sites and Properties Identified in the Cedar River Watershed

CRW Site No.	Smithsonian No.	Site Name	Site Type	NRHP* Evaluation Status	CRW Management Recommendation ***
3		Taylor Townsite	Town	Potentially Eligible	A
5		Landsburg RR Crossing	RR Crossing	Not Eligible**	C
7		18.3 Homesteads	Homesteads	Not Evaluated	B
11		Tillie Chapman Grave	Grave; Homestead	Not Evaluated	B
		(Homestead)		Not Evaluated	B
16		Louis Ek Homestead	Homestead	Not Evaluated	B
19		M. Galloway Homestead	Homestead	Not Evaluated	B
		Chester Morse Lake Archaeological District	District	Determined Eligible	
25	45KI25	45KI25	Hunter-gatherer	CMAD+	A
26	45KI26H	F. Damburat Homestead	Homestead	Not Eligible	C
27	45KI27	45KI27	Hunter-gatherer	CMAD+	A
28	45KI28H	Cedar Lake Logging Co.	Camp-Logging	Not Eligible	C
29	45KI29	45KI29	Hunter-gatherer	CMAD+	A
30	45KI30	45KI30	Hunter-gatherer	CMAD+	A
31	45KI31	45KI31	Hunter-gatherer	CMAD+	A
32	45KI32	45KI32	Hunter-gatherer	CMAD+	A
33		Hi Ho Site	Hunter-gatherer	Not Evaluated	A
34		City Cabin Dump	Dump	Not Eligible**	C
35		Mt. Lindsay Site	Hunter-gatherer	Not Evaluated	A
46		Ghost Camp	Camp-Logging	Not Evaluated	B
50		Walsh Depot & School	School/R.R. Community	Not Evaluated	B
63		N.F. Pumphrey	Homestead	Not Evaluated	B
65		(F. Nesbit?) House	House	Not Evaluated	B
72		K. Wells/Damburat Cabin	Cabin	Not Evaluated	B
77		Dump (Bear Creek Cabin)	Historic Cabin	Not Evaluated	B
92		Sherwood Townsite	Town	Not Evaluated	A
93		Milem Homestead (?)	Homestead	Not Evaluated	B
96		Bay View Brewing Co./Saloon (Sherwood)	Town/Saloon	Not Evaluated	A
97		Saw Repair (Filing) Shack	Logging	Not Evaluated	B
104		Water Intake for Taylor	Hydropower	Not Evaluated	B
105		Mountain Tree Farm	Camp-Logging	Not Eligible**	C
107		Walsh Lake Ditch		Not Evaluated	B
129		Robinson Mine - Mary Earhart	Mining	Not Eligible**	B
134		510 Road Mine and Mining Cabin	Mining	Not Evaluated	B
139		Camp 18	Camp-Logging (Japanese)	Not Evaluated	B
140A		Camp 12, earlier	Logging Camp	Not Evaluated	B
141		Camp 20	Camp-Logging	Not Evaluated	B
149		Wm. Molloy Homestead	Homestead	Not Evaluated	B
150T		Cedar River Pack Trail (McClellan Trail)	Trail	Not Evaluated	B
151T		Rex River Trail	Trail	Not Evaluated	B
152T		South Crest Line Trail	Trail	Not Evaluated	B
153T		Meadow Pass Trail	Trail	Not Evaluated	B
154T		Boulder Creek Trail	Trail	Not Evaluated	B

Table 3.6-2. Hunter-Fisher-Gatherer and Historic Archaeological Sites and Properties Identified in the Cedar River Watershed

CRW Site No.	Smithsonian No.	Site Name	Site Type	NRHP* Evaluation Status	CRW Management Recommendation ***
157		Shaft Tunnel	Mining	Not Evaluated	B
158		Shaft	Mining	Not Evaluated	B
160		Viola/Bridal Veil Mine	Mining	Not Eligible**	C
161		Mine	Mining	Not Evaluated	B
163		Camp No. 4	Camp-Logging	Not Evaluated	B
164		Brown Bear?/Eureka Mine	Mining	Not Evaluated	B
165		Townsley Mine	Mining	Not Evaluated	B
166		Rack Creek Site	Hunter-gatherer	Not Evaluated	A
167		On Line/Woodline Mines	Mining	Not Evaluated	B
168		Drain ditch from dam on N. Fork of Hotel Creek	Watershed Mgmt.	Not Evaluated	B
173		Stripped Cedar Site	Hunter-gatherer	Not Evaluated	A
185		M. Creedican House	House	Not Evaluated	B
201		Railroad Camp	Town	Not Eligible	C
202		Last Chance Mine	Mining	Not Evaluated	B
203		Stripped Cedars	Hunter-gatherer	Not Evaluated	A
204		Oriole Mine	Mining	Not Evaluated	B
286	45KI286H	45KI286H	Camp/Dump-Logging	Not Eligible	C
287	45KI287H	Camp II	Town	Not Evaluated	C
288A	45KI288H	Camp I	Town	Not Eligible	C
289	45KI289H	Camp II Dump	Dump	Not Eligible	C
290	45KI290	Cedar River Rockshelter	Hunter-gatherer	Not Evaluated	A
298	45KI298	Rex River Delta Arch. Site	Hunter-gatherer	Not Evaluated	A
299	45KI299	Cedar River Levee Arch. Site	Hunter-gatherer	Not Evaluated	A
300	45KI300	Green Point Creek Arch. Site	Hunter-gatherer	Not Evaluated	A
434A	45KI434A	Moncton Townsite	Town	Not Eligible**	C
434B	45KI434B	Rainy Season Lake Site	Hunter-gatherer	Not Eligible**	C

*NRHP-National Register of Historic Places

+CMAD-Chester Morse Lake Archaeological District

**OAHP Concurrence Not Concluded

434A, B-Site Components

***A-Requires Consultation with OAHP and professional cultural resources specialist to determine evaluation and/or mitigation measures.

B-Requires field assessment by cultural resources technician and/or evaluation by professional archaeologist.

C-Requires a Determination of Effect or property has been determined not eligible.

D-No management requirements.

T-Transportation Feature

Table 3.6-3. Locations of Historic Activities in the Cedar River Watershed

CRW Site No.	Site Name	Site Type	Assessment Needed	CRW Management Recommendation*
4	Barneston Townsite and Millpond	Town	Yes	A
8	A. Barber House	Homestead	Yes	B
9	Bear Creek Cabin	Cabin	No**	C
10	J. E. Bell Homestead	Homestead	Yes	B
12	City Cabin Location	Cabin	No	C
13	Jim Clark Homestead	Homestead	Yes	B
14	Camp	Camp	Yes	B
15	Davis Homestead	Homestead	No	C
17	Camp	Camp	Yes	B
18	Gaffney Homestead	Homestead	Yes	B
20	H. Bothman House	House	Yes	B
21	Camp	Camp	Yes	B
22	Graham Homestead	Homestead	No	C
23	Wm. Hamilt House	House	Yes	B
24	Jones Homestead	Homestead	Yes	B
36	Bear Camp	Camp	Yes	B
37	Rack Creek Camp	Camp	Yes	B
38	Cabin	Cabin	Yes	B
40	Rex Lake Camp	Camp	Yes	B
41	Iolanthe	R.R. Community	Yes	B
42	Hemlock	Town (Japanese)	Yes	A
43	Japanese Camp	Town (Japanese)	Yes	A
44	Trude	R.R.	Yes	B
45	Hyak Shingle Mill	Shingle Mill; Logging	Yes	B
47	Camp	Camp-Logging	Yes	B
48	Walsh Homestead	Homestead	Yes	B
49	Camp	Camp-Logging	Yes	B
51A	Peter Hay Homestead/Shingle Mill	Homestead	Yes	B
52	Cabin	Cabin	Yes	B
53	Cabin	Cabin	Yes	B
54	House and Barn	Homestead	Yes	B
55	Fremont Kelly Homestead	Homestead	Yes	B
56	Frank King Homestead	Homestead	Yes	B
57	J.C. McBean Cabin	Cabin	No	C
58	McCarty Homestead	Homestead	Yes	B
59	Milem Homestead (?)	Homestead	Yes	B
60	Mitchell Cabin	Cabin	Yes	B
61	W. Muncaster; Two Houses	Homestead	Yes	B
64	Rex River Cabin	Cabin	Yes	B
66	A.M. Saunton; Two Houses	Homestead; Bridge	Yes	B
67	Frank King Cabin (P. King?)	Cabin	Yes	B
68	L. Shafer Cabin	Cabin	No	C
69	South Fork Cabin	Cabin	Yes	B
70	Maggie Thrasher Cabin	Cabin	Yes	B
71	Geo. W. Treen House	House	Yes	B
73	K. Wells House	House	Yes	B
74	Young House	House	Yes	B
75	Ashbridge (?) Cabin(s)	Homestead	Yes	B

CRW Site No.	Site Name	Site Type	Assessment Needed	CRW Management Recommendation*
76	Weaver Cabin	House	Yes	B
78	Cabin	Cabin	Yes	B
79	Cabin	Cabin	Yes	B
80	Cabin	Cabin	Yes	B
81	Mathias Shuck Cabin	Cabin	Yes	B
82	Cabin	Cabin	Yes	B
83	Cabin	Cabin	Yes	B
84	Two Cabins	Cabin	Yes	B
85	Cabin	Cabin	Yes	B
86	Cabin	Cabin	Yes	B
87	Cabin	Cabin	Yes	B
88	Road Camp/"Jap Camp"	Camp (Japanese)	Yes	B
89	Morse Cabin	Cabin	No	C
90	Cabin	Cabin	Yes	B
91	Fort Tilton	Encampment	No	C
94	Camp	Camp	Yes	B
98	Cabin in clearing	Cabin	Yes	B
99	Spaulding Homestead	Homestead	Yes	B
100D	Crib Dam	Hydroelectric Works HAER #WA15	Not Eligible	C
102	Camp	Camp	Yes	B
106	Dam at Rock Cr. & Walsh Lk. outlet	Dam	Yes	B
108	Dam on N. Fork of Hotel Creek	Dam	Yes	B
109	Dam on Williams Creek	Dam	Yes	B
110	Logging Camp		Yes	B
111	School		Yes	B
112	Cabin	Cabin	Yes	B
113	Cabin	Cabin	Yes	B
114	Richard Turner Cabin	Cabin	Yes	B
115	Cabin	Cabin	Yes	B
117	Cabin	Cabin	Yes	B
118	Cabin	Cabin	Yes	B
119	Cabin	Cabin	Yes	B
120	"Shack"	"Shack"	Yes	B
121	Nordrum's "New" Cabin	Cabin	No	C
122	Cabin	Cabin	Yes	B
123	Saloon & clearing	Business	Yes	B
124	John Fleming Cabin	Cabin	Yes	B
125	Steele Homestead; Three Houses	Homestead	Yes	B
126	Frank Brackett Cabin	Cabin	No	C
127	Cabin, probably "Old" Nordrum Cabin	Cabin	No	C
128	Cabin	Cabin	Yes	B
130	Cedar Falls Campground	Camp	Yes	B
131	Nesbit? Cabin	Cabin	Yes	B
132	Cabin	Cabin	Yes	B
133	Cabin	Cabin	Yes	B
135	Cabin	Cabin	Yes	B
136	Cabin	Cabin	No	C

CRW Site No.	Site Name	Site Type	Assessment Needed	CRW Management Recommendation*
137	School		Yes	B
140B	Camp 12, later	Camp-Logging	Yes	B
142	Cabin	Cabin	Yes	B
143	Camp	Camp	Yes	B
144	Cabin in clearing	Cabin	Yes	B
146	Camp No. 3	Camp-Logging	Yes	B
147	Cabin with Trail	Cabin	Yes	B
148	House with Trail	House	Yes	B
155	Two Cabins	Cabin	Yes	B
156	Two Cabins	Cabin	Yes	B
159	Cabin	Cabin	Yes	B
162	Cedar Point Lookout		Yes	B
169	Cabin	Cabin	Yes	B
171	Snoose Junction	Logging	No	C
172	House	House	Yes	B
178	Pedro Felise Cabin	Cabin	Yes	B
180	Cabin	Cabin	Yes	B
181	Cabin	Cabin	Yes	B
182	Cabin	Cabin	Yes	B
183	Cabin	Cabin	Yes	B
184	Cabin	Cabin	Yes	B
186	Camp	Camp	Yes	B
187	Powell Cabin	Cabin	Yes	B
189	Homestead	Homestead	Yes	B
190	House	House	Yes	B
191	Bridge over Cedar R. at Landsburg	Bridge	Yes	B
192	Sullivan's Cabin	Cabin	Yes	B
193	Two Cabins	Cabin	Yes	B
194	Cabin	Cabin	Yes	B
195	Bridge over Cedar R.	R.R. Bridge	Yes	B
196	Cabin	Cabin	Yes	B
197	W.R. Meeken Cabin	Cabin	Yes	B
198	Cabin/Mine Prospect	Mining	Yes	B
199	500 Road Cabin Site	Cabin	No	C
200	Halfway House	Cabin	Yes	B
205	Bagley Junction	Railroad	Yes	B
207	Little Mountain Lookout	Lookout	Yes	C
208	CCC Camp Milan	CCC Camp	Yes	B
209	Pacific States Lumber Co. Trestle	Logging Trestle	Yes	C
288B	Camp I (1912-1914)	Town	Yes	B
288C	CCC Cedar Lake	CCC Camp	Yes	B

**A-Requires Consultation with OAHP and professional cultural resources specialist to determine evaluation and/or mitigation.
B-Requires field assessment by cultural resources technician and/or evaluation by professional archaeologist.
C-Requires a Determination of Effect or property has been determined not eligible.
*No-Location has been field assessed and no remains exist.

Table 3.6-4. Historic Structures Identified in the Cedar River Watershed

CRW Site No.	Site Name	Site Type	NRHP* Evaluation Status	CRW Management Recommendation**
1A	Cedar Falls	Town	Potentially Eligible+	A
1B	Railroad Structures-Cedar Falls	Railroad	Not Evaluated	B
1C	Water Management Structures-Cedar Falls	Watershed Mgmt.	Not Eligible	C
1D	City Cabin	Cabin	Not Evaluated	B
51B	Walsh Lake Nursery	Watershed Mgmt.	Not Evaluated	B
62	O' Brien + Bridge	Homestead	Not Evaluated	B
	Cedar Falls Power Plant Historic District	Hydroelectric Works	Determined Eligible	
100A	Masonry Dam	Hydroelectric Works HAER #WA15	Determined Eligible	A
100B	Penstock and Related Structures	Hydroelectric Works HAER #WA15	Determined Eligible	A
100C	Power Plant and Related Structures	Hydroelectric Works HAER #WA15	Determined Eligible	A
103	Landsburg Waterworks	Water Management	Evaluation in Progress (Probably Eligible)	A

*National Register of Historic Places

+Potentially Eligible for Listing on the NRHP

100A, B, C-Site Components

**A-Requires Consultation with OAHP and professional cultural resources specialist to determine evaluation and/or mitigation.

B-Requires field assessment by cultural resources technician and/or evaluation by professional archaeologist.

C-Requires a Determination of Effect or property has been determined not eligible.

3.7 Land Use

3.7.1 Introduction

The proposed HCP may influence the manner and pattern of both primary and secondary land uses currently occurring in the Watershed. Since its first acquisition in the Watershed in 1898, the City of Seattle has actively pursued land ownership and implemented management policies with the primary goal of protecting the availability and quality of it municipal water supply. Through a combination of operating agreements with other landowners and a program of property acquisition, the City placed increasingly strict conditions on activities within the Watershed. With the completion of land acquisition in 1996, the City is now the sole manager of lands within the Watershed, effectively protecting the Watershed from future development.

The primary use of the Watershed is to provide a reliable high quality supply of water to the region. The Watershed is also used by the City to generate a relatively small amount of hydroelectric power (see Section 3.9, Public Services). Secondary to these uses, the predominant land use in the Watershed historically has been commercial timber production. Some adjacent lands are now experiencing suburban development (e.g., Wilderness Rim). The lower Cedar River below Landsburg Diversion has been affected by floodplain alterations and urban development. Land use regulation in this area falls under the jurisdiction of King County, City of Maple Valley, and the City of Renton.

The first section below summarizes key King County and City of Seattle land planning documents and zoning requirements for the area. The second section describes existing activities and land use of the area, including the Cedar River Municipal Watershed from Cascade Ridge to Landsburg Diversion and lands adjacent to Cedar River from Landsburg Diversion to the river's mouth at Lake Washington.

A discussion of potential effects on land use resulting from the adoption of the Applicant's proposed HCP or any of its alternatives is presented in Section 4.7. Generally, the adoption of the proposed HCP or any of its alternatives will not affect or will be consistent with regional and local land use plans.

3.7.2 Land Use Plans and Zoning

Land use activities in the Watershed and surrounding areas are governed and influenced by a variety of planning and regulatory programs. Comprehensive plans define the goals, objectives, and policies for existing and future land uses. Subarea plans and functional plans define more detailed goals, objectives, and policies.

Zoning ordinances comprise the regulatory code that implements the various planning documents. The Washington Growth Management Act requires consistency between planning documents and land use regulations. The following sections briefly describe key planning documents and zoning ordinances with jurisdiction over land uses within and adjacent to the Watershed. In general, the land use activities proposed in the HCP do not conflict with existing land use goals, objectives, and policies.

King County Comprehensive Plan

In 1994, King County adopted a new comprehensive plan as required to comply with the Washington Growth Management Act of 1990. Though the Cedar River Municipal Watershed is owned by the City of Seattle, the use of the land in the Watershed is regulated by the County. Consistency requires compliance with the County's Land Use Plan and the County's zoning designations for the Watershed. In the King County Zoning Atlas (February 2, 1995), the Seattle City Cedar River Municipal Watershed and surrounding land is zoned F-Forest. The purpose of this classification is "to preserve the forest land base, to conserve and protect the long-term productivity of forest land, and to restrict the uses unrelated to or incompatible with forestry" (21A.04.040). The Forest Zone also allows compatible outdoor recreation uses, the protection of municipal Watersheds, and the conservation of fish and wildlife species and their habitats.

Tahoma/Raven Heights Community Plan

The Cedar River Municipal Watershed is primarily located in a portion of the county referred to as Tahoma/Raven Heights Area. The original Tahoma/Raven Heights Community Plan (King County, 1984) will be updated to comply with the 1994 King County Comprehensive Plan in the near future.

King County Shoreline Management Master Program

The Washington State Shoreline Management Act of 1971 (RCW 90.58) identifies statewide policies to foster reasonable and appropriate use of shorelines with jurisdiction typically 200 feet from the ordinary high water mark of "shorelines of the state." Except for Hobo Creek which is designated as Rural under King County's Shoreline Management Master Program, , all shoreline areas within the Cedar River Municipal Watershed are designated Conservancy. The purpose of the Conservancy designation is to protect, conserve, and manage existing natural and historic/cultural resources associated with the shoreline.

King County Open Space Plan

The King County Open Space Plan (King County, 1996) sets forth policies and plans for the development of a county-wide system of parks and open space. Lands along the Cedar River from the outskirts of Renton to Landsburg are designated as an open space corridor system. This document identifies plans to establish the Cedar River Trail.

Cedar River Trail Plan

The Cedar River Trail Plan, adopted by King County as part of the King County regional trails system, sets forth a program for a coordinated trail system from the mouth of the Cedar River at Lake Washington to the ridge crest north of the Watershed boundaries.

Rattlesnake Mountain Scenic Area

The Rattlesnake Mountain Scenic Management Plan prepared jointly by the Washington Department of Natural Resources and King County provides for low impact educational and recreational uses of the 1,800 acre scenic area.

3.7.3 Other Planning Documents Affecting Land Use

In addition to land use plans, there are other planning documents that affect land use in the Watershed. In particular, the City's direction for management of the Watershed is contained in the *Cedar River Watershed Secondary Use Analysis* (Seattle Water Department, 1990) and the *Water Supply Plan* (Seattle Water Department, 1993a). The following sections summarize the land use objectives defined in these two documents.

Cedar River Municipal Watershed Secondary Use Analysis

In 1986, the City of Seattle adopted the 1985 Comprehensive Plan, which directed the City to conduct an analysis of "secondary" land uses for the Cedar River Municipal Watershed. Following completion of the study, the Seattle City Council adopted an amendment to the Comprehensive Plan in July 1989 (Ordinance 114632; Technical Appendix 12). The adopted City policies for secondary use addressed watershed management, timber resources, vegetation management, fire management, wildlife and botanical resources, fisheries resources, education, recreation, scientific research, and cultural resources. Collectively, these policies supported the City's two primary objectives for the Cedar River Municipal Watershed:

1) to manage the Watershed to ensure the supply of high quality water without requiring additional treatment.

2) to provide a significantly large natural area in the Cedar River Municipal Watershed to protect all existing species, to provide opportunities for education and research that emphasize the unique features of the area, to pursue a habitat acquisition and preservation program, and to conduct a long-term timber harvest program on designated City-owned second growth lands.

In order to prevent contamination of the public drinking water supply, the key policy supporting the primary objective prohibits any unsupervised public access within the Watershed. All activities, including the construction and maintenance of existing water supply and electric generating facilities, the harvesting of timber, the City's educational program, and scientific research must be overseen by City personnel.

Clearly, implementation of the second objective focused on protecting and preserving the natural environment. The adopted policies recommended that over half of the land within the Watershed, including all of the old growth forest stands, should be placed in a Reserve status, where commercial timber harvest would not be allowed. Long-term timber harvesting activities could occur only within second growth stands located outside of the Reserve area and revenues from this timber program would initially be dedicated to the acquisition of National Forest System lands located within the boundaries of the Watershed. The policies also call for efforts to protect wildlife species inhabiting the Watershed; to protect, restore, and enhance fish and wildlife habitats; to expand the education program; to develop a cultural resources management plan; to make improvements to recreational facilities outside the closed watershed boundaries; and to construct a new interpretive center at the Rattlesnake Lake Park.

City of Seattle Water Supply Plan

In 1993, the City adopted the Water Supply Plan (Seattle Water Department, 1993a) to guide efforts to provide customers with the desired quantity and quality of drinking water. The three objectives of this planning document are 1) to provide a safe and reliable supply of high quality drinking water, 2) to protect the environment, and 3) to protect the long-term financial position of the utility and the economic interests of rate payers. The four implementation guidelines of the Water Supply Plan are listed below:

- Integrate the management of all resources to ensure protection of all and to produce the best combination of benefits.
- Protect resources by developing specific standards, objectives, and operating guidelines; monitor the effects of management actions to measure success in meeting these objectives and standards; and adapt resource management based on knowledge obtained in follow-up monitoring.

- Recognize the differences in needs and beliefs among interest groups and public agencies, and be responsive to these needs where consistent with overall land management policies and objectives.
- Develop effective mechanisms for participation of the public, affected interest groups, and public agencies in decision-making regarding resource management.

In addition, the Water Supply Plan recommends specific actions that should be taken in the near-term to begin to implement the Water Supply Plan. The development of the proposed HCP for the Cedar River Municipal Watershed represents a major effort towards implementing the City's Water Supply Plan.

3.7.4 Existing Land Use

The following discussion is divided into three sections. The first section describes existing land uses within the Watershed. The second section describes land uses adjacent to the Watershed. And the third section describes land uses adjacent to the Cedar River downstream of Landsburg Diversion.

Watershed Land Uses

The existing condition of the land and the uses within the Cedar River Municipal Watershed result from the activities of past property owners and City of Seattle activities and policies. In 1889, the City approved a bond issue to purchase a portion of the upper basin of the Cedar River to secure a source of high quality water. Similar to other areas in Western Washington at that time, the Watershed area had begun to attract homesteaders, timber companies, and mining prospectors. Railroad lines had been constructed and small towns had been established. The predominant land use of the Watershed had historically been forestry.

In 1898, the City made its first land purchase in the upper watershed of the Cedar River. By condemnation order, land was acquired to construct a diversion dam and pipeline intake at a location known as Landsburg in the westernmost boundary of the Watershed. With completion of the transmission pipeline to Seattle, the first water flowed to the City of Seattle in 1901. The year before, the City initiated development of a hydroelectric power plant in the Watershed with the purchase of lands along the river between Landsburg and Cedar (Morse) Lake and lands around the lake's shore. A power plant was completed at what would later become the headquarters for City operations, Cedar Falls. Electricity generated at the plant began to flow to Seattle in 1904 (see Section 3.9, Public Services). Masonry Dam was constructed to replace a timber crib structure and was completed in 1914. The dam increased the capacity of the lake as a water supply reservoir and increased the hydroelectric capacity of the Cedar Falls Power Plant.

By 1912, most of the smaller private landholdings in the Watershed had been acquired by the City through condemnation proceedings. The last non-City community was abandoned in 1946 when the City purchased the property rights of the clay and coal mining and manufacturing town of Taylor. As with the other land purchases, buildings were razed and evidence of former habitation was allowed to be subsumed into the forest. The last private land in the Watershed was acquired by the Applicant in 1991 when Weyerhaeuser and Scott Paper Company timberlands were purchased. The last USFS acreage was turned over to the Applicant in 1996. Today the City of Seattle owns 90,546 acres of land. Within the boundaries of the properties now encompassed in the Cedar River Municipal Watershed, only the property rights to an abandoned railroad right-of-way running along the river from Cedar Falls to Landsburg remain outside of the Applicant's legal control.

Protection of the public water supply remains the Applicant's single-most important objective guiding land use in the Watershed (Seattle Water Department, 1992). The watershed boundaries are posted as "No Trespassing" and all road access points are gated and locked. Most of the westerly boundary is fenced. Watershed inspectors patrol the area daily to enforce the "no access" policy. Legitimate access into the Watershed is authorized only by permit or participation in supervised public education programs. Permitted activities are carefully monitored and must follow strict sanitary, fire, and hazardous substance control regulations.

Permitted activities in the Watershed follow the guidelines adopted in the 1989 by the Seattle City Council as presented in the *Cedar River Watershed Secondary Use Policies* (see Technical Appendix 12). Research on natural resources is conducted primarily by the University of Washington at two facilities set aside for this purpose: (1) the Monahan Findley Lake Research Area in the old growth forest at Findley Lake, and (2) the Thompson Research Center east of the Landsburg Diversion. Research on cultural resources has been conducted by contract archaeologists and students from several universities. Cedar River Municipal Watershed Public Programs' staff supervise approximately 10,000 people a year in educational programs, primarily students from Seattle Public Schools and outlying school districts within the Watershed's water distribution area. The public programs use a limited number of watershed sites, where sanitary facilities are provided. Public recreation is only allowed at two locations, Rattlesnake Lake and a park downstream of the Landsburg Diversion. Both of these areas are outside of the hydrologic boundary of the Watershed and are discussed in more detail in Section 3.8, Recreation.

Cedar Falls is located at the end of Cedar Falls Road south of I-90 and is accessed by Exit 32. It is the base of operations for the activities of both Seattle City Light and Seattle Public Utilities in the Watershed. Seattle City Light operates the power plant at Cedar Falls, Masonry Dam, and the water transmission pipelines (penstocks) that supply water from Masonry Dam to the power plant. Seattle Public Utilities employees are responsible for a number of activities including the following: (1) watershed protection (monitoring for trespass and other potential water supply or water quality problems); (2) maintenance of roads, culverts, and other infrastructure; (3) forestry and wildlife management; (4) management of cultural resources; and (5) public education and information. Contracted services for these activities are permitted under, strict regulations.

Land Uses Adjacent to the Watershed

Lands near the Watershed are owned by individuals, natural resource agencies, the federal government, and timber companies (see Map 3). Much of the land is forested. Some is protected wildlife and fisheries habitat and some is subject to industrial logging practices. Properties have been acquired by various government agencies for recreational activities including the Mountain-to-Sound Greenway, the John Wayne Trail, the Iron Horse Trail, and the Rattlesnake Mountain Scenic Area (see Section 3.8, Recreation). In addition, suburban development pressures have resulted in significant growth in nearby North Bend and eastern King County.

Land Use Adjacent to the Cedar River Below Landsburg

Downstream of Landsburg Diversion, the Cedar River traverses a wide variety of land uses. Long segments of the river are dedicated open spaces and agricultural lands. In Maple Valley, the river meanders through historic rural settlements as well as newer large lot subdivision. As the river approaches the City limits of Renton, the land use pattern transitions to smaller lot residential subdivisions, developed parks, and golf courses. In Renton, the river is mostly channelized through residential and commercial development. In fact, Renton’s municipal library building spans the river channel. Land uses adjacent to the river as it empties into Lake Washington are heavy commercial uses, including manufacturing. The development of property adjacent to the Cedar River below Landsburg Diversion is regulated by King County and the City of Renton.

3.7.5 Summary

The current land uses in the Watershed are consistent with King County Land Use Plan designations as well as King County’s zoning regulations. These uses also are consistent with the City’s adopted policies for secondary uses in the Watershed and the City’s Water Supply Plan. Proposed activities incorporated in the Applicant’s proposed HCP will be assessed for consistency with existing land uses or land use plan and zoning regulations; however, generally the adoption of the proposed HCP or any of its alternatives will not affect adjacent land uses and will be consistent with regional and local land use plans. A discussion of the potential effects on land use resulting from the implementation of the proposed HCP or any of its alternatives is presented in Section 4.7.

3.8 Recreation

3.8.1 Introduction

The waters from the Cedar River Municipal Watershed ("Watershed") flow to Lake Washington and out the Hiram Chittenden Locks to the Puget Sound (see Map 2, Volume 3, Resource Maps). Along this path to the ocean, there are abundant recreational opportunities. Popular activities include hiking along the water's edge and fishing, boating, and swimming in the water. For purposes of analysis, these recreational activities are divided into water-dependent recreational activities and water-enhanced recreational activities depending on the amount of water flow required.

In general, the quality of each type of recreational experience is influenced by the amount of water flowing in the river channel. The depth and velocity of the water determine the character of the river. Low flows allow the river to slowly meander within its channel and encourage lush vegetation to establish along the riverbanks. In contrast, high flows keep the channel scoured, transport rocks and sediments, and can alter riparian habitat. Among the many recreational activities that occur along the Cedar River to Lake Washington and beyond to the Puget Sound, only some depend on water flow while others are enhanced by the water flow (Shelby et al., 1992).

Water-enhanced recreational activities include picnicking, hiking, biking, bird watching, and camping. These activities occur year-around, rain or shine. The character of the water does not preclude any of these activities. Rather, the depth and velocity of the water help define the recreational experience. The river water is only one element that contributes to defining the quality of the recreational experience.

In contrast, swimming, tubing, fishing, and boating are the water-dependent recreational activities. These activities are entirely linked to the amount, depth, temperature, velocity, and quality of water. Different variables, however, are more or less important for each type of recreation experience (Shelby et al., 1992). For example, swimming and tubing call for warm water and the hot days of late summer. Boating activities are most closely tied to the amount of water flowing, especially in a river. Fishing can occur at various times of the year.

The following sections describe the affected recreational environment in and around the Cedar River Municipal Watershed, the Cedar River Basin below the Landsburg Diversion, Lake Washington, and waters linking Lake Washington to the Puget Sound. The types of recreation activities that may be affected by the proposed alternatives include picnicking, hiking, bird watching, camping, boating, and fishing. The analysis of potential impacts are described in Section 4.8.

3.8.2 Cedar River Municipal Watershed

The Cedar River Municipal Watershed above the Landsburg Diversion is primarily owned by the City of Seattle. The land is mountainous, forested, and unpopulated. Smaller rivers and creeks flow in the many subbasins of the Watershed to the very large Chester Morse Lake. The management of the Watershed and Masonry Dam can impact the water quality, peak flows, and aquatic habitat of the mainstem of the Cedar River below Landsburg Diversion, in Lake Washington, and in the waters linking Lake Washington and the Puget Sound.

Except for one small area within the City-owned portion of the Cedar River Basin, unauthorized public access to the Watershed is prohibited. As such, the Watershed is not available for public pursuit of recreational opportunities. Public water systems are required to comply with the provisions of the Federal Safe Drinking Water Act (SDWA) and its associated regulations, such as watershed protection requirements (see Section 3.2.2 Water Quality). A small portion of the City-owned land near Rattlesnake Lake, however, lies outside of the hydrographic boundary of the Watershed (Seattle Water Department, 1991). This area was opened for public recreation by the City in 1970. The 33.5-acre Rattlesnake Lake Recreation Area is accessed via Interstate 90 and the Cedar Falls Road.

This recreation area will continue to be a day-use facility for picnicking, swimming, boating (no gasoline engines), and fishing. Rattlesnake Lake, however, is fed by groundwater from Chester Morse Lake. Consequently, the water level varies an average of 31 feet in a year, depending on the water level of the reservoir. The lowest level typically occurs in later summer or early fall. Each spring, the Washington State Department of Fish and Wildlife stocks the lake with rainbow trout. In addition, hikers can access the Rattlesnake Ledge Trail that traverses City-owned land and connects to a Rattlesnake Mountain trail (Manning, 1987).

Site improvements are planned for this recreation area. In 1998, a trail will be constructed to connect the Snoqualmie Valley Trail Extension and the Iron Horse State Park/John Wayne Trail that skirt the Watershed's northern boundary. The Washington State Parks Department will construct a trailhead at the new regional trails' junction. Recreational and interpretive trails will connect the Rattlesnake Lake area to the planned Cedar River Municipal Watershed Education Center. Construction of the interpretive center will begin in 1999.

3.8.3 Cedar River Basin Below Landsburg Diversion

In contrast to the limited recreation available in the Cedar River Basin above Landsburg Diversion, recreation opportunities are numerous along the 22-mile shoreline of the Cedar River from Landsburg downstream to the mouth of the river at Lake Washington. This portion of the Cedar River Basin comprises approximately 66 square miles of land, or approximately one-third of the total basin. Both the City of Renton and King County have parks along the banks of the river. The paragraphs below describe the types of parks and recreational opportunities available along this stretch of the Cedar River.

Parks and Open Space

Below Landsburg Diversion, the City of Seattle owns a small public park, the Landsburg Park (Seattle Water Department, 1991). This 6-acre park is located just 0.2 mile downstream from the dam. The park offers picnicking and swimming to daytime visitors only. Visitors to the park may view sockeye, coho, chinook salmon, steelhead, and cutthroat trout. In past years, the park also has hosted summer day camps. Outside of the City's Watershed and downstream at Hobart-Ravensdale Road Bridge, there is a put-in for kayakers to run a state-recognized kayak slalom race course.

Further downstream in unincorporated King County, there are several large parks and open space Reserves along the south bank of the Cedar River (Automobile Association of America, 1993). Near the communities of Elliott and Cedar Mountain, King County owns two large tracts of land located between the south bank of the Cedar River and State Highway 169 that comprise the Cedar River County Park. Along this stretch of the river, there also are two private campgrounds, the Aqua Barn Ranch (200 camp sites) and the River Bend Park (50 camp sites) (DeLorme Mapping Company, 1995). Further upstream, King County has purchased lands, including Elliott Jungle and Indian Forest, for future development of parks or continued informal use as undeveloped open space lands. Upstream from the Cedar Grove Park, visitors can walk along undeveloped railroad right-of-way to the Titanic Cliffs (200 feet) and the Great Gravel Cliff (150 feet) along the river.

Just before the river joins Lake Washington, it flows through the City of Renton. Near the City limits, the Maplewood Golf and Country Club abuts the river. In the City center, the river connects three urban parks (Jones, Liberty, and Cedar River parks) near the intersection of the Maple Valley Road and Interstate 405 (DeLorme Mapping Company, 1995). In addition, there is a public boat ramp at the mouth of the river. Between these points, the river is channelized and there is an asphalt trail along the shoreline for walking, jogging, in-line skating, and bicycling (Manning, 1988). King County plans to extend the Cedar River Trail all the way to the Landsburg Diversion, a distance of approximately 15 miles, using an old Burlington Northern Railroad right-of-way (Personal communication, Sharon Clausen, King County Parks and Recreation Department, September 24, 1997).

Recreation Activities

As described above, there are a wide variety of recreational opportunities available for outdoor enthusiasts along the Cedar River below Landsburg Diversion. The Proposed HCP Alternative would likely affect these recreational opportunities in only a limited fashion. The proposed alternatives for watershed management are directed towards timber harvesting practices and habitat restoration and protection in the Cedar River Municipal Watershed and would not affect recreational opportunities along the Cedar River below Landsburg Diversion. The alternatives proposed for anadromous fish mitigation are actions aimed to improve the fisheries of the Cedar River. Considering the river is closed to recreational fishing, these alternatives would not negatively affect recreational opportunities along the Cedar River below Landsburg Diversion (see below). The alternatives for instream flow, however, could affect water-dependent recreational opportunities. As such, a more detailed discussion of these types of recreational activities is provided in the following paragraphs.

In the Cedar River below Landsburg Diversion, the most popular water-dependent recreational activities include swimming, tubing, wading, rafting, canoeing, and kayaking. Due to the temperate weather conditions in the Seattle area, swimming, tubing and wading generally are limited to a short season in late summer. Various boating experiences, however, occur throughout the year.

The Cedar River has been an extremely popular boating river for decades. Row boats, canoes, rafts, and kayaks are common boats used on the Cedar River. River conditions are not universally conducive to all types of boating. Different flows can affect the size and number of pools and rapids in the river channel as well as the potential exposure of gravel bars. During the warm months of late spring and summer, row boats, rafts, and canoes are common. In the late summer, low instream flow typically exposes gravel bars, which become obstacles for these boaters. When water levels are high during the winter and early spring months, kayaking is very popular, particularly between the Landsburg Diversion and Maple Valley (Bennett, 1991). Because of the narrow river channel and overhanging vegetation upstream from Maple Valley, the Cedar River is not frequently used for whitewater rafting. There are several boating seasons on the Cedar River that correlate to different seasonal water levels and the optimal flow level for one activity may exclude another.

Past and recent streamflow measurement records made by the United States Geological Survey (USGS) show that daily flow values fluctuate widely in the

Cedar River below Seattle's Landsburg Diversion Dam. Flows have ranged from a maximum 10,600 cfs to a minimum 30 cfs within the water year 1946 to 1996 period of record measured at the USGS Stream Gage No. 12119000 in the Cedar River at Renton. Streamflow statistics and graphs of actual daily flow values for water years which generally represent high, median and low flow years for the Cedar River are included in Section 3.2.1 and help illustrate these wide variations in streamflows.

Based on these flows and the characteristics of the river channel, the Cedar River is rated as a Class II river (Bennett, 1991). For kayakers, this is the novice rating that requires little scouting as rapids are straightforward and channels are clear. In contrast, a Class III river (intermediate) has rapids with moderate and irregular waves that can swamp a canoe or require complex maneuvers to ensure kayakers have control of their boats. In *A Guide to the Whitewater Rivers of Washington* (Bennett, 1991), Judy Fillips recommends kayakers run the Cedar River between Landsburg and Maple Valley when flows are between 400 cfs and 1,000 cfs. When flows are 350 cfs or below, she says boaters must carry boats over gravel bars. For those boating recreationalists floating down the river in a raft, canoe, or row boat, a portage is often just part of the experience. Kayakers, however, want to run the rivers when the water is high and fast-moving because the speed and the use of their technical skills define the quality of the experience.

Historically, fishing in the Cedar River was very popular and some very large salmon and game fish have been caught in the river. Sockeye, coho, and chinook salmon, steelhead, and cutthroat trout all inhabit the river. In the 1980s, however, the fish runs for these species declined dramatically (see Section 3.4, Fisheries Habitat and Resources). As a result, the WDFW re-evaluated the recreational fishing regulations governing the river. The agency conducted studies to determine if the size of specific fisheries could survive with continued recreational fishing. Based on these detailed studies, the WDFW decided to close the Cedar River to recreational fishing for all fish species in the early 1990s. If the overall health and strength of these fisheries improve significantly in the future, the WDFW has the option to reopen the river to recreational fishing.

For all water-dependent activities, water flow also poses safety risks for recreational enthusiasts. For those wading in the shallow water, high water levels may only mean a switch from boots to waders. But for swimmers and boaters, high flows tend to increase the likelihood of accidents. The sudden changes in water level from storms, flash floods, and changes in water releases at upstream dams (ramping) can catch all recreationalists off-guard and can result in potentially life-threatening accidents. For this reason, staff of Seattle

Public Utility, Seattle City Light, and the King County Surface Water Management Agency work closely together to manage water flows and prevent downstream surges of water volume.

3.8.4 Lake Washington to Puget Sound

Water-related recreation opportunities on Lake Washington and the waterways that link the lake to Puget Sound are closely tied to instream flows of the Cedar River. Historically, this was not the case. A number of different watersheds drained into Lake Washington, which drained to the south, via the Black and Duwamish rivers, to the Puget Sound. At that time, the Cedar River drained directly into the Black River. The construction of the Lake Washington Ship Canal and the Hiram M. Chittenden Locks in the early years of this century allowed both commercial and pleasure boats to travel between Puget Sound and Lake Washington. These public works projects also lowered the water level of Lake Washington and changed the drainage course of both Lake Washington and the Cedar River. Today, the Cedar River flows directly into Lake Washington, which now drains via the Lake Washington Ship Canal and the locks. Supplying approximately 50 percent of all source waters of Lake Washington, the Cedar River influences water-related recreational opportunities in and adjacent to Lake Washington and the waters linking the lake to Puget Sound.

Parks and Open Space

Both large and small parks dot the shores of Lake Washington. Major parks include the University of Washington Arboretum, the City of Seattle's Warren S. Magnuson Park, St. Edwards State Park, Big Finn Hill County Park, the City of Kirkland's Juanita Bay Park, the Mercer Island Luther Burbank Park, the Mercer Slough Nature Park in Bellevue, the Gene Coulon Memorial Beach Park in Renton, and the City of Seattle's Seward Park (American Automobile Association, 1993). The lake is popular with all types of boating enthusiasts for sailing, rowing, sea kayaking, and canoeing. Yacht clubs, marinas, and public boat ramps dot the shoreline. Many other smaller City and county parks ring the shores of Lake Washington. In addition, the shoreline Burke-Gilman Trail provides a path for walkers, joggers, and bicyclists from Kenmore at the north end of the lake, south to the University of Washington campus, and continues west along the north shore of Portage Bay and Lake Union. In addition, both commercial sightseeing companies and privately-owned float planes are moored at special harbors located on the southern shore of Lake Union, the north end of Lake Washington in Kenmore, and the south shore of Lake Washington adjacent to the Renton Municipal Airport.

The waterways linking Lake Washington to Shilshole also are lined with recreational facilities. There are marinas for pleasure craft at the University of Washington Boating Center, Portage Bay, Lake Union, and Shilshole. The University of Washington Arboretum extends to the water's edge and includes a nature path through the marshes. People walk and fish from riverside paths at the Montlake Bridge and the Fremont Bridge. The Hiram M. Chittenden Locks is a popular place to view salmon, cutthroat trout, and steelhead fish as they migrate up the fish ladder. Visitors also can view the daily operation of the locks for commercial and pleasure craft and can listen to band concerts during the summer months. Picnicking, ball games, and swimming are popular at Golden Gardens Park near the Shilshole marina. All of these recreational opportunities add to the quality of life enjoyed by Seattle area residents.

Recreation Activities

Visitors to the parks and open spaces around Lake Washington and the waterways linking the lake to Puget Sound can enjoy a wide variety of recreation activities including picnicking, biking, hiking, swimming, canoeing, various organized and informal sports, and wildlife viewing. The Proposed HCP Alternative, though, would likely affect these recreational opportunities in only a limited fashion. The proposed alternatives for watershed management are directed towards timber harvesting practices and habitat restoration, which would not affect off-shore or on-shore recreational opportunities for these waters. The alternatives for instream flow would not directly affect water-dependent recreational opportunities, despite the fact that the river contributes a large portion of the inflow to Lake Washington. The operation of the Hiram M. Chittenden Locks is dependent upon specific water levels in Lake Washington and is closely coordinated with many state and local agencies, including the City of Seattle Public Utilities. The remaining alternatives proposed for anadromous fish mitigation, though, could affect recreational fishing in Lake Washington.

Around Lake Washington, there are many sites to go fishing. Popular spots include the following: Kenmore's Log Boom Park; Seattle's Magneson Park, Seward Park, and Rainier Beach; Renton's Marina Park and Gene Coulon Park; Kirkland's Waverly Park; and Mercer Island's Luther Burbank Park (WDFW, 1997). During peak seasons, hundreds of anglers fish from private boats.

Numerous game fish species inhabit Lake Washington. Species include coho salmon, sockeye salmon, chinook salmon, rainbow trout, steelhead trout, cutthroat trout, large mouth bass, small mouth bass, yellow perch and others. The fish prized by anglers are rainbow trout, cutthroat trout, steelhead, sockeye, chinook, and coho salmon. The discussion below is only a brief description of these fish (Fresh, 1994).

- Sockeye Salmon. This fish is the most important fish in Lake Washington. The origin of the sockeye population in the lake is the result of a planned introduction. About 80 to 90 percent of the Lake Washington sockeye salmon spawning activities occur in the Cedar River. The sockeye salmon is harvested both commercially, primarily by Native American Indian Tribes, and recreationally.
- Coho Salmon. This fish is the second most abundant anadromous species in Lake Washington and contributes significantly to recreation, sport, tribal fishing, and non-Indian commercial harvesting. Both wild

and hatchery fish are caught. The population of wild coho has declined substantially in recent years.

- Chinook Salmon. This fish is highly prized for its large size and flavorful flesh. Of the three salmon species found in Lake Washington, this fishery is the smallest in size and the survival of this fishery appears to be at risk. In the past decade, chinook returns to Lake Washington have declined to about one-third of their historic levels. Currently, this species is under review to become a federally listed species under the Endangered Species Act.
- Trout. This fishery is the dominant species caught by anglers in Lake Washington. Many of the trout caught are rainbow and cutthroat. The cutthroat are sustained by natural production, while the rainbow trout originate from hatcheries. Despite the negative effects of urbanization on fisheries habitat in the Lake Washington basin, the cutthroat trout is thriving.
- Steelhead Trout. This species is not heavily fished, though it is prized for the fight given by the fish when caught. The fish is much more popular as a recreational fish than a tribal fish. Local hatcheries have reared this species since the early decades of this century.

In Washington, it is the State Department of Fish and Wildlife that regulates recreational fishing. The Department regulates both who may fish and what fish may be caught. The Department requires all sports fishermen over 14 years of age to purchase a fishing license. Relative to fishing in Lake Washington, there are potentially three difference types of licenses required. A food fish license is required to fish for anadromous salmon. A game fish license is required for rainbow trout, cutthroat trout, landlocked salmon, bass, and others. A separate fishing license is required for steelhead fishing. The Washington Department of Fish and Wildlife also levies additional license fees to support fisheries enhancement programs in Puget Sound and Lake Washington. Rather than limit the number of fishing licenses issued, the Washington Department of Fish and Wildlife limits the length of time a fishery is open to manage the fishery.

The Washington Department of Fish and Wildlife also monitors the health of fisheries. The agency tracks species popular with sport fishermen and assesses the viability of the fishery. To protect the survivability of the fishery, the agency regulates the size, daily catch limit, and season for recreational fishing. Each year, the recreational fishing regulations are published in *Fishing in Washington.*

Of the recreational trout fisheries of Lake Washington, the cutthroat trout are sustained by natural production, and the population of the species is increasing. The rainbow trout originate from hatcheries and harvest levels appear to fluctuate with the planting level (Fresh, 1994). On Lake Washington, game fishing is open year-round and the daily catch is limited to five fish (WDFW, 1997). Between March 1 and June 30, the fish must exceed 12 inches in length. In addition, steelhead and rainbow exceeding 20 inches in length between December 1 and June 30 must be released. Future regulation of game fish in Lake Washington is anticipated to be similar to these limitations.

Coho salmon populations in Lake Washington have declined substantially in recent years, especially for wild coho. Historic studies document that the population peaked at over 30,000 in 1970, but declined to less than 2,000 in 1992 (Fresh, 1994). Despite this decline, recreational fishing for this food fish has continued in recent years. The legal season to fish for coho salmon in Lake Washington, however, is quite limited. Moreover, only two fish may be caught per day. Recommended 1998 recreational fishing regulations are unchanged from these limitations (WDFW, 1997). Season openings are dependent on fish abundance.

As described above, the sockeye salmon is the most important fish in Lake Washington. Since the 1920s, there have been efforts to establish a major sockeye run in Lake Washington. In 1967, the Washington Department of Fisheries began to actively manage the fish run so that harvest limits could be established. Since that time, total returns (catch plus escapement) have ranged up to 680,000 fish, though the recreational fishery has been permitted only intermittently (Fresh, 1994). In all, over the past 30 years, the recreational fishery has been open only 13 occasions. In the past decade, the sockeye salmon fishery has been open in 1988 and 1996. In those years, the size of the sport catch was estimated to be over 71,000 and 74,000 fish, respectively (see Table 3.10-3). Clearly, this recreational fishery is sporadic at best in Lake Washington.

Recreational fishing in the Lake Washington Ship Canal between the Montlake Cut and the Hiram M. Chittenden Locks is regulated separately from Lake Washington fisheries (WDFW, 1997). Regulations for game fish are the same as those described for Lake Washington. The area is completely closed to recreational fishing for any type of food fish, e.g., anadromous salmon. In addition, the regulations for the 1998–1999 fishing season are anticipated to be the same as for 1997.

3.8.5 Summary

The above discussion described the wide variety of recreational opportunities that could be affected by the implementation of the proposed HCP. The proposal includes alternatives to watershed management, anadromous fish mitigation, and instream flow. The potential effects of these alternatives are focused on boating activities in the Cedar River below Landsburg Diversion and recreational fishing in Lake Washington and the waterways connecting the lake to Shilshole Bay. The evaluation of potential effects on boating opportunities will examine the variability of flows during the year, the specific boating experiences available during different seasons, and the seasonal duration of each type of boating experience. The evaluation of potential effects on recreational fishing in Lake Washington and the waterways linking the lake to Shilshole Bay will assess the potential likelihood that the proposed watershed management programs, fisheries habitat restoration and protection activities, and instream flows will sustain or improve the long-term survivability of fisheries currently in demise. An evaluation will also determine whether any proposed measures could result in the reopening of currently closed recreational fisheries. The analysis of the potential effects on recreational opportunities that would arise from the several alternatives of the proposed HCP are discussed in Section 4.8.

3.9 Public Services

3.9.1 Introduction

There are three public services provided by the City of Seattle associated with the management of the Cedar River Municipal Watershed above the Landsburg Dam. These services are water for municipal and industrial purposes, flood control, and electric energy generation. The Cedar River Municipal Watershed supplies public drinking water to the residents of Seattle, adjacent cities, and a number of water purveyors in King County. The City's operation of Masonry Dam contributes to flood control along the Cedar River downstream of the dam. In addition, Seattle City Light operates a hydroelectric generating plant that uses water.

The various proposed project alternatives would affect water storage, availability, use, and management of the Cedar River. In turn, these changes could affect the City's ability to supply potable water to its Seattle and King County customers, to generate electricity to meet the energy demand of residents and businesses of Seattle and adjacent cities, and to manage Masonry Dam operations to control flooding. The following sections describe these public services in more detail. The potential effects on these public services from implementing Proposed HCP Alternative are discussed in Section 4.9.

3.9.2 Seattle Public Utilities—Potable Water

The Cedar River supplies approximately 70 percent of the potable water required to supply Seattle's water customers. The utility currently supplies water to more than 1.2 million people throughout King County and a small part of Snohomish County (Seattle Water Department, 1993a). About 49 percent of this water is used in single-family homes; another 15 percent in multifamily dwellings; 28 percent by commercial and industrial customers; and 8 percent by government and institutional customers (Seattle Water Department, 1993a).

SPU sells potable water directly to the City's residences and commercial and industrial businesses. These customers comprise the City's retail customers. The City also has wholesale customers. In all, the City of Seattle has long-term water service contracts with 26 different water purveyors in King County.

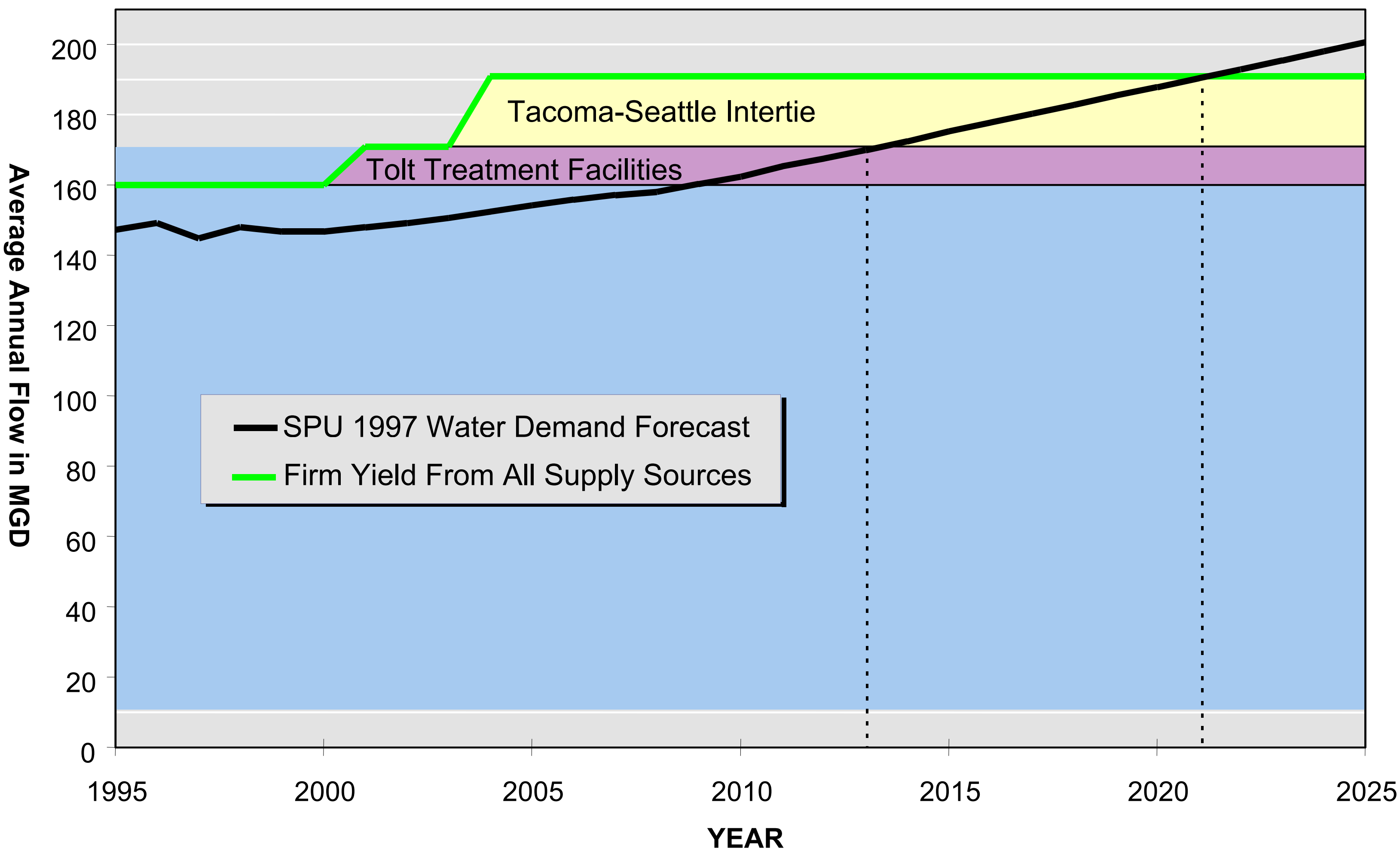
Most of the purveyors are either municipal water departments or independent water districts. These purveyors purchase approximately 40 percent of Seattle's available water at wholesale rates and sell the water at retail rates to their customers. The water sales contracts between Seattle and its purveyors expire after 2012.

Except for adding the City of Redmond in 1987, the City's wholesale water service area has remained relatively constant since the mid-1960s. Growth in the number of direct service customers has resulted primarily from increased population density and increased business (commercial and industrial) activity. The actual increase in number of customers has averaged about one percent per year in recent years. Despite the increase in customers, the overall demand for water has been generally stable with very little increase, due to an active conservation program, improved system operations, and higher water rates. Seattle's role as a regional water supplier includes planning to meet forecasted demand. When Seattle's current water supply contracts with its purveyors expire in 2012, the responsibility to develop new supplies and demand management programs will be shared between the City and a new regional water agency, still in a formative state, known as the Cascade Water Alliance (CWA). The City will be responsible for its direct service area, and the Cascade Water Alliance will be responsible for developing regional solutions to water supply needs. If CWA forms prior to 2012, some of the City's purveyor contracts may be superseded by the agreement between the City and CWA.

Water suppliers need a planning tool that allows them to assess system capacity to meet demand. The City, like other water suppliers, typically measures its source capacity in terms of "average annual firm yield." This intentionally conservative measure is used as a planning tool to represent the volume of water that would be reliably available under all but the very most adverse circumstances from a given source or combination of sources. In the modeling environment, average annual firm yield is the average daily quantity of water reliably available throughout the year under defined system operating conditions and constraints. Worst case conditions are defined as those hydrologic conditions that, given the 65-year record of data for the Watershed, would be expected to occur in no more than 2 percent of the years. Average annual firm yield is not a measure of how much water would be available in any one year, a predictor of real-time operations, nor an indicator of water use reductions. The most recent firm yield estimate, for the total water system as it is currently configured, is 160 million gallons per day (MGD). For the system as it will exist in the year 2000, when the Tolt Treatment Facilities come on line, the firm yield estimate is 171 MGD.

The supply and demand projections until 2020 are shown in Figure 3.9-1. The supply line represents the average annual firm yield of the water supply

Figure 3.9-1. Seattle Regional System - Supply and Demand Projections for 1995 to 2025



system. The demand line represents the actual and forecasted average annual demand (as of 1997) of the City and its existing purveyors.

3.9.3 Seattle Public Utilities—Flood Control

The Applicant's primary water management goals are to provide high-quality, reliable, and adequate supplies of drinking water for its customers, and to protect and enhance fish habitat. Any efforts directed towards the management of flows for flood protection are considered secondary and must be compatible with the City's primary missions. The City of Seattle has a limited ability to manage and control flood waters in the Cedar River below the Landsburg Diversion due to the design and function of the Overflow Dike, Masonry Dam, and Landsburg Diversion.

Of the three facilities in the Watershed, Masonry Dam has the greatest capacity to influence instream flow in the Cedar River. The dam impounds water in Masonry Pool, and Chester Morse Lake, which is small compared to the size of the Watershed. The most significant factor affecting the City's ability to control instream flows and prevent downstream flooding relates to the comparative size of the Watershed and reservoir storage capacity. This is generally a surprise to people who are familiar with the operation of other regulated rivers in western Washington. For example, the Tolt and Green Rivers have large storage reservoirs relative to their basin sizes and the operation of the reservoir dams provides greater flexibility to control flooding. This size difference between the reservoir and the watershed basin is the key that permits management and control of downstream flows. Subbasins in the Watershed that do not drain into Chester Morse Lake, drain directly into the mainstem of the Cedar River (e.g., Taylor Creek).

Operation of this reservoir causes the water level to fluctuate between 1,500 and 1,570 feet, and allows the City to modify stream flow in the mainstem of the Cedar River to some degree. Water is released through the hydroelectric plant, a valved pipe that bypasses the power house, or the service and emergency spill gates of the dam.

Landsburg Diversion is a run-of-the river design. It impounds water released from Masonry Dam as well as the subbasins that drain into the mainstem of the Cedar River below Masonry Dam. In all, the amount of water impounded is extremely small and only facilitates diversion of public drinking water. This diversion dam does not provide significant storage or reregulation of flows. Basically, the Landsburg Dam passes all flows over the dam in excess of water supply needs. During periods of high turbidity in the river, or during facility maintenance, diversion may cease altogether.

Overall, risks to flooding of the Cedar River below Landsburg Diversion have increased over time. Historic attempts to control flood flows were to protect farmland from the meandering course of the river. In more recent decades, however, suburban development has increased flows in the Cedar River. In fact, suburban development changes surface water drainage patterns. The construction of roads and houses reduce ground permeability and surface water infiltration. In turn, the peak volumes and the duration of peak flows increase. The construction of levees, channels, and armoring the riverbank have helped to control flood conditions, but have not eliminated flooding problems.

Because of the constraints discussed here, the risks associated with flooding of the Cedar River continue to the present day. Flooding threatens human lives, damages infrastructure, and takes a substantial economic toll on homes and businesses. During major flood events, approximately several hundred homes are at some level of significant risk from mainstem flooding (Seattle Water Department, 1993). Renton's municipal buildings, the Boeing Renton Plant, and the Renton's municipal airport are also at risk to flood damage and/or disruption of commercial activity.

To alleviate the flooding effects downstream of Masonry Dam, the City of Seattle, the King County Division of Natural Resources, the City of Renton, and the Corps of Engineers have increasingly worked together to control flood damage along the river. In 1990 the Thanksgiving Day flood of the Cedar River exceeded all previous records since construction of the Masonry Dam in the early part of this century. The new data prompted the revision of all hydrologic models of the river so they would more accurately predict potential flood events.

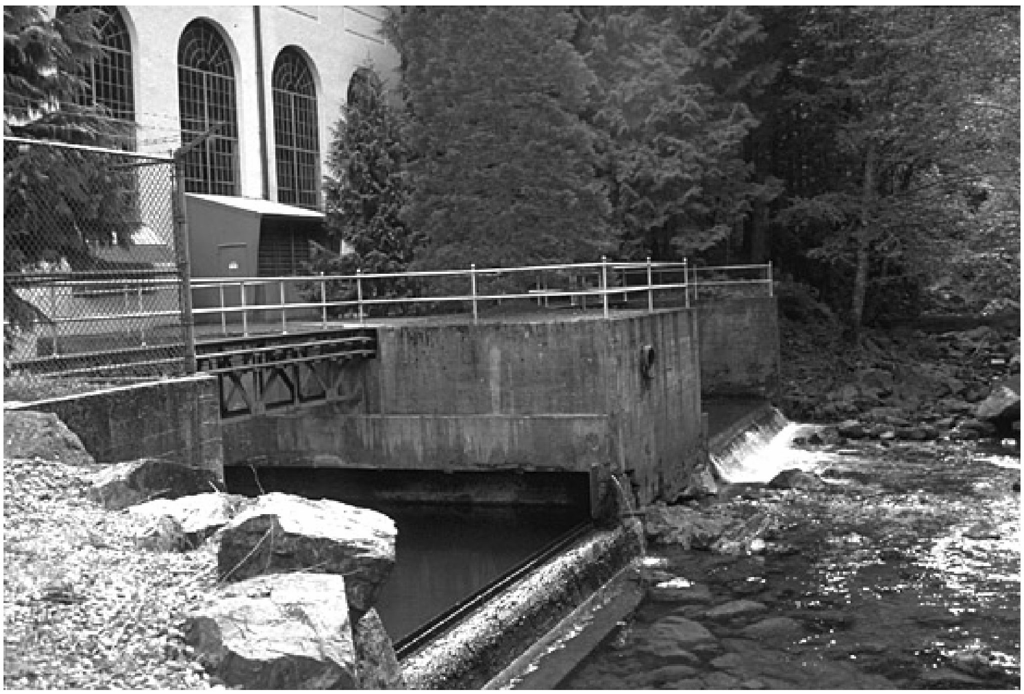
The Cedar River's natural 100-year flood discharge is estimated to be approximately 18,000 cfs. The City of Seattle's Watershed dams, King County's levees and riverbank armoring, and Renton's channeling of the river have converted the Cedar River Basin into a highly managed system. Under today's managed conditions, the 100-year flood discharge is estimated to be approximately 11,000 cfs.

Flood conditions in the Cedar River also can contribute to flooding in Lake Washington. As mentioned above, flow from the river constitutes approximately half of the inflow to the lake. The water level in the lake, however, is largely controlled by the Hiram Chittenden Locks. The operation of the locks can maintain the lake water level and release water to prevent flooding. Because of this, flooding issues related to the Cedar River are primarily limited to the lands adjacent to the mainstem of the river downstream of Landsburg Dam.

3.9.4 Seattle City Light—Hydroelectric Generating Plant

Since 1904, Seattle City Light has operated a hydroelectric generating plant in the Watershed at Cedar Falls. This run-of-the-river generating plant was the City's first. Initially the plant capacity was only 2.4 MW, but strong demand allowed the utility to expand the facility. With the construction of the Masonry Dam, the utility was able to capitalize on the storage reservoir to increase generating capacity by an additional 8 MW. In 1921 and in 1929, turbine generators were installed to replace the original generators. These new facilities increased the total plant capacity to 30 MW.

Today, the Cedar Falls Hydroelectric Plant continues to operate with the turbines installed in the 1920s. The facility is unmanned, though the utility maintains 24-hour supervisory electronic monitoring. The energy generated at the plant is interconnected with the Puget Sound Energy (formerly Puget Sound Power & Light Company) electric transmission system via a 115 kV transmission line. In turn, the Puget Sound Energy grid interconnects with the Seattle City Light transmission system.



Cedar Falls hydroelectric power plant

The Cedar Falls Hydroelectric Plant is operated independent of water diversions for public drinking water. During normal conditions, water flows from Chester Morse Lake and Masonry Pool, through the penstocks at Masonry Dam to the power plant below at Cedar Falls. Flows in excess of volumes required to operate the power plant spill over the dam or flow directly into a bypass pipeline. The water continues to flow downstream another 12 miles to the public water supply intake at the Landsburg Diversion Dam, where a portion of the flow is diverted for water supply.

Seattle City Light currently serves more than 640,000 people with 330,000 customers within a service area of 131 square miles. This service area includes the City of Seattle and seven adjacent municipalities. In all, the utility generates approximately 58 percent of the energy needed to meet current demand while the remainder of the energy required to serve its customers is purchased, primarily from the Bonneville Power Administration.

The Cedar Falls Hydroelectric Plant provides less than 1 percent of the total energy needs of the utility.

3.9.5 Summary

The supply of potable water, the generation of electricity at the Cedar Falls Hydroelectric Plant, and flood control on the Cedar River are interrelated issues. Implementation of one or more of the alternatives of the proposed HCP could have direct effects on the City's capacity to meet future customer demand for both potable water and electricity. Similarly, the Proposed HCP Alternative could potentially affect flood control on the Cedar River downstream of Masonry Dam. The discussion of effects on public services resulting from the adoption of the proposed HCP is found in Section 4.9.

3.10 Socioeconomic Conditions

3.10.1 Introduction

This chapter assesses the socioeconomic conditions within the study region—defined as King County with special attention to the City of Seattle—over the period 1980 to 1996. Potentially significant socioeconomic impacts likely to be caused by the development and implementation of the proposed HCP in the Cedar River Municipal Watershed are evaluated later in Section 4.1l in terms of the baseline conditions described in this section.

Salient findings within this chapter include:

- Population increases and economic growth generally translate into increased demand for water. Despite steady population growth and increased economic activity since 1982 in King County, water demand has remained relatively constant before dropping off sharply in 1992 due to the drought. Since 1992, the combined effects of higher water rates, conservation efforts, and improved system conditions have kept both billed and total consumption below predrought levels. For the Cedar River—which supplies 70 percent of the SPU's water—the result is an actual decline in overall water demand.
- In the Cedar River Municipal Watershed, the area is entirely undeveloped with no residents and will remain so for the foreseeable future with or without the proposed action.
- Natural resource industries contributes a decreasingly smaller share of total economic activity within King County. Timber harvests in King County have declined and now represent less than half of the 1988 peak harvest. Within the Cedar River Municipal Watershed, timber harvests have fallen to less than 200 thousand board feet (less than one one-hundredth percent of King County's annual total) (see Figure 3.10-6).
- Likewise, commercial and recreational/sport fisheries within Puget Sound, and specifically, Lake Washington, are significantly reduced from its past levels. With the exception of 1996, the sport sockeye fishery on Lake Washington amounts to less than one percent of all

recreational freshwater angling within the Puget Sound region. Consequently, the economic activity derived from commercial and sport fishing has become almost negligible.

- Water rates are established by City ordinance and are currently sufficient to meet anticipated operations and maintenance expenses and current debt service obligations.

3.10.2 Population

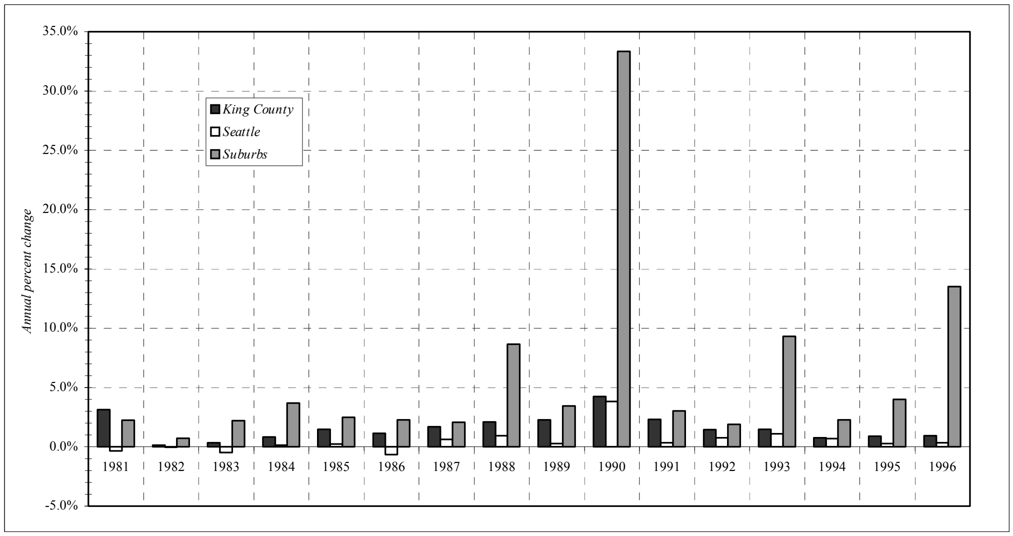
King County is Washington State's most populated county and represents its largest economy. In 1996, the Washington State Office of Financial Management estimated the population of King County at 1,628,800 people. This represents an increase of 358,902 since 1980, which is an average annual growth of 1.8 percent, compared with the overall average annual growth of 2.1 percent for Washington State. The majority of King County population growth consists of net in-migration from other areas. Since 1980, over 63 percent of the county's growth was due to population in-migration.

Population growth is unevenly distributed around King County. The majority of King County's growth is being captured by suburban cities through annexation and new construction. With 662,000 people, the suburban cities have far more people than the City of Seattle (534,700) or unincorporated King County (431,910). Since 1980, the average annual growth rate of suburban population is nearly 9 percent (Figure 3.10-1). Annexations and recent incorporations (e.g., Burien, Newcastle, Shoreline, Woodinville) played a significant role in these gains.

In contrast, the City of Seattle continues to grow slowly; its population is now only 9 percent larger than its recent low point of 1986. With 534,700 people, Seattle has increased by only 41,000 people since 1980. Seattle, however, is expected to continue gaining population; more than one-fifth of the County's new housing units since 1990 are slated for Seattle, due in large part to provisions of the Washington State Growth Management Act. The Cedar River Municipal Watershed area above the Landsburg Dam is owned by the City of Seattle. The Watershed is entirely undeveloped with no residents and will remain so for the foreseeable future, with or without the proposed HCP.

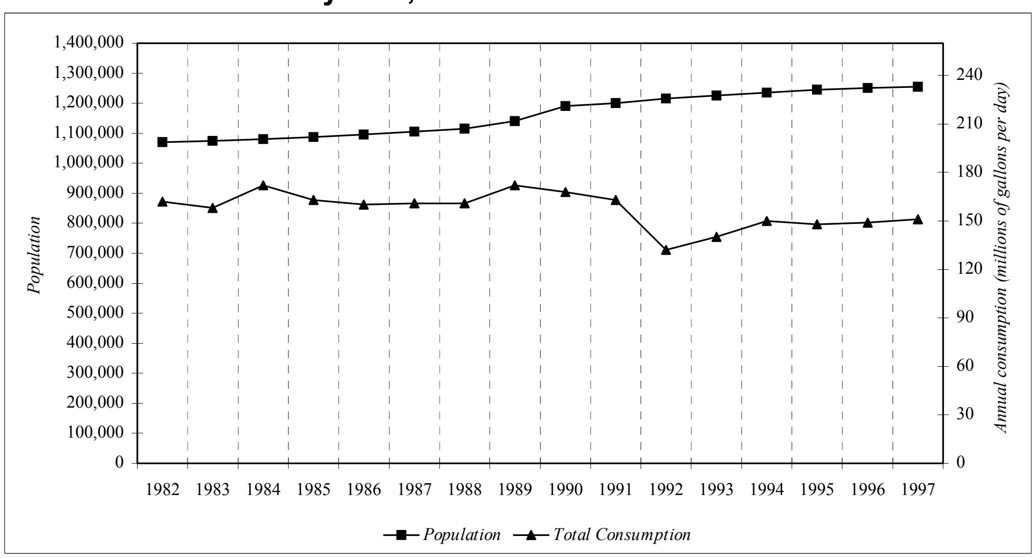
Despite steady population growth since 1982, water demand has remained relatively constant except for the significant drop in 1992 due to the drought. Since then, the combined effects of higher water rates, conservation, and improved system operations have kept total consumption below predrought levels (Figure 3.10-2).

Figure 3.10-1. Annual Population Change for King County, City of Seattle and Suburbs, 1981-1996



Source: Washington State Office of Financial Management. *Population Trends*, various years.

Figure 3.10-2. Growth in Population and Water Consumption, Seattle Water System, 1980-1997



Source: Seattle Public Utilities.

Population Growth Forecast

Current forecasts from the State Office of Financial Management anticipate that by the year 2020 the population of King County will exceed 2.0 million people; with 57 percent of the increase due to new in-migrants (Table 3.10-1). Population growth in King County is expected to be slower between 1995 and 2020 (26 percent or 1.01 percent annual rate) than in the previous twenty-five years (39 percent or 1.6 percent annual rate).

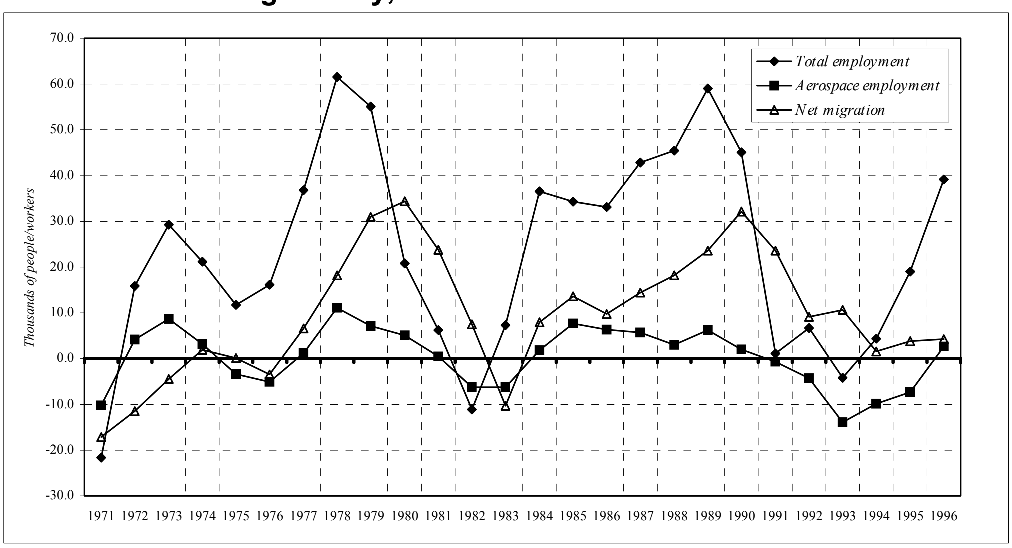
Table 3.10-1. King County Population, 2000-2020

	2000	2005	2010	2015	2020
Population	1,679,065	1,763,634	1,840,176	1,929,924	2,030,675
Net Migration	29,046	53,545	43,526	51,136	60,035

Source: Washington State Office of Financial Management. Washington State County Population Projections by Age and Sex: 1990-2020. 1995 Projections. Olympia, WA. 1996.

In-migration will likely be a significant factor in future population growth in King County. Between 1970 and 1995, more than 70 percent of King County's population growth stemmed from net in-migration. More people have come into King County than have left in all but 5 of the last 26 years. Net migration into the county has grown steadily due largely to economic factors, specifically aerospace hiring and layoffs. Figure 3.10-3 shows how net in-migration drops in years of significant aerospace layoffs and surges in years of aerospace hiring. Although King County's employment base is currently more diversified than in previous decades, aerospace (specifically, Boeing) employment levels continue to be monitored as an important economic and demographic barometer for the local area.

Figure 3.10-3. Total and Aerospace Employment and Net Migration in King County, 1971-1996

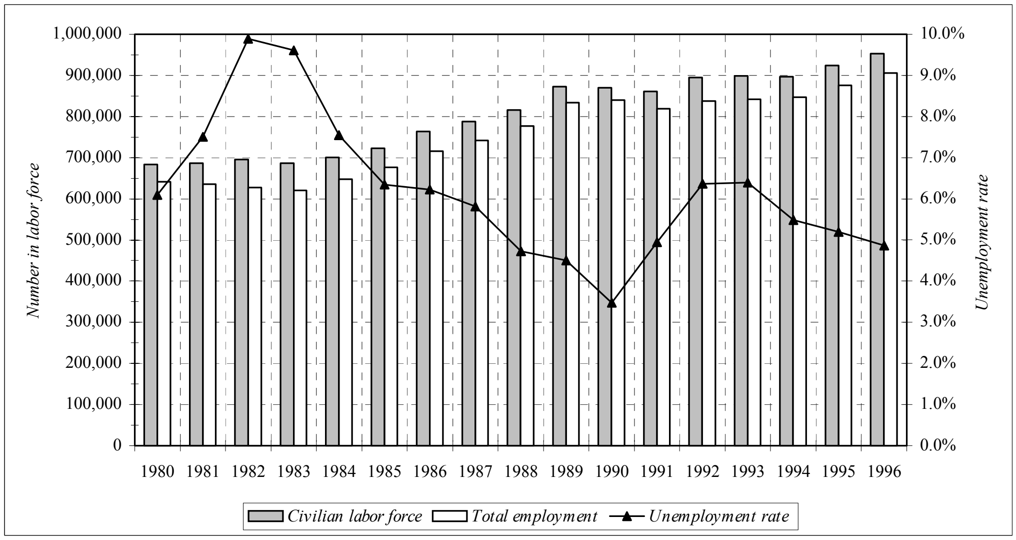


Sources: Washington State Employment Security Department, Labor Market & Economic Analysis Branch; Washington State Office of Financial Management; and Puget Sound Regional Council.

3.10.3 Labor Force and Unemployment

The labor force is defined as the sum of all persons 16 years and over residing in a given place, whether they are employed or unemployed. The definition excludes homemakers, full-time students, and persons residing in institutions. The labor force in King County has steadily grown; since 1980, the labor force has grown much faster than resident population, with an average annual growth rate of 2.4 percent. After four years of sluggish growth, King County's labor market experienced a dramatic turnaround in 1996 and 1997. Substantial numbers of new entrants to the labor force and the creation of new jobs significantly lowered the County's unemployment rate to under 5 percent in 1996 (Figure 3.10-4).

Figure 3.10-4. Civilian Labor Force in King County, 1980-1996



Source: Washington State Employment Security Department, Labor Market & Economic Analysis Branch. *Labor Force and Employment in Washington State*, various years.

3.10.4 Employment

After enjoying a significant period of employment growth during the mid and late 1980s, King County's economy stagnated between 1990 and 1994 with few employment gains and increasing unemployment (Figures 3.10-3 and 3.10-5). With the national economy in recession in 1990 to 1991 and the state's leading manufacturing sector (aerospace) struggling during the early 1990s, King County added only 15,400 new jobs between 1990 and 1994, representing on average an annual growth rate of less than one percent.

1995 marked a major turnaround year for King County as the local economy added over 20,000 new jobs to its non-agricultural workforce. In 1996, total employment in King County grew by 35,500 (3.6 percent annual growth rate) to reach 1,013,900 nonagricultural wage and salary jobs. This marks the first time the number of nonfarm wage and salary jobs in King County has passed the one million milestone (Washington State Employment Security Department).

The county's employment mix has shifted over time (Table 3.10-2). In 1980, more than a quarter of the total jobs in King County were in the goods-producing sectors of resources (e.g., agriculture, mining, fishing, forestry), manufacturing, and construction. By 1996, the employment share of goods-producing sectors had dropped to under 20 percent. This shift was not caused by a reduction in manufacturing or construction; rather, it resulted largely from growth in the service-producing sectors. Manufacturing accounted for 19.5

percent of all jobs in 1980, compared with 13 percent in 1996. While slightly diminished in relative importance, construction and resources have experienced modest employment growth. Employment in service-producing sectors (consisting of transportation and public utilities; wholesale and retail trade; finance, insurance, and real estate; services; and government) has grown by four percent each year since 1980.

Figure 3.10-5. Total Employment in King County, 1980-1996

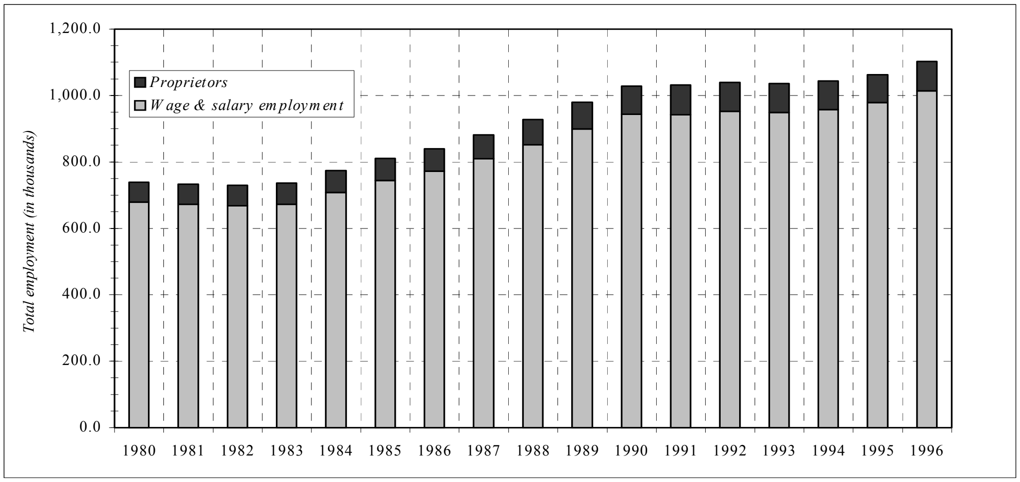


Table 3.10-2. Employment in King County by Major Industry Groupings, 1980-1996 (in thousands)

Year	Total	Natural Resources	Construct	Manu-facturing	Transport & Public Utilities	Wholesale & Retail Trade	Finance, Insur & Real Estate	Services	Government
1980	747.8	6.4	43.4	146.0	50.9	180.9	58.1	150.2	111.9
1981	754.0	6.1	41.0	143.8	50.2	184.4	58.9	158.4	111.3
1982	742.9	6.1	37.9	134.0	50.6	183.1	58.7	162.9	109.7
1983	750.2	5.7	38.5	125.5	50.9	186.2	60.0	172.5	110.9
1984	786.7	5.3	42.5	129.7	52.5	195.1	62.6	184.8	114.2
1985	821.0	5.0	45.1	135.6	53.9	199.2	64.8	199.1	118.5
1986	854.2	5.5	49.5	141.6	55.5	205.4	67.9	208.2	120.6
1987	897.0	5.5	51.8	149.1	57.1	213.5	69.5	225.8	124.7
1988	942.4	6.8	56.4	156.9	59.5	223.5	69.0	241.9	128.4
1989	1,001.4	7.1	60.5	169.6	65.3	234.2	71.6	261.5	131.7
1990	1,046.6	8.9	64.1	173.3	66.9	242.3	72.6	280.5	137.9
1991	1,047.7	9.8	64.0	169.2	66.5	241.2	71.4	285.2	140.4
1992	1,054.4	8.9	65.2	164.0	67.1	240.6	72.2	292.1	144.3
1993	1,050.2	7.6	62.1	151.8	66.9	243.4	73.0	300.0	145.3
1994	1,054.6	7.6	59.9	143.6	68.5	248.6	72.9	308.2	145.3
1995	1,073.6	7.1	59.0	139.9	70.9	255.8	71.2	322.5	147.1
1996	1,112.8	6.9	60.9	144.2	73.1	262.8	71.7	343.8	149.3

Note: Includes both wage & salary employment and proprietors.

Sources: Washington State Employment Security Department, Labor Market & Economic Analysis Branch. *Labor Force and Employment in Washington State*, various years; Puget Sound Regional Council. *Regional and County Employment Database, 1958-1996*; U.S. Department of Commerce, Bureau of Economic Analysis. Regional Economic Information System, 1969-1995.

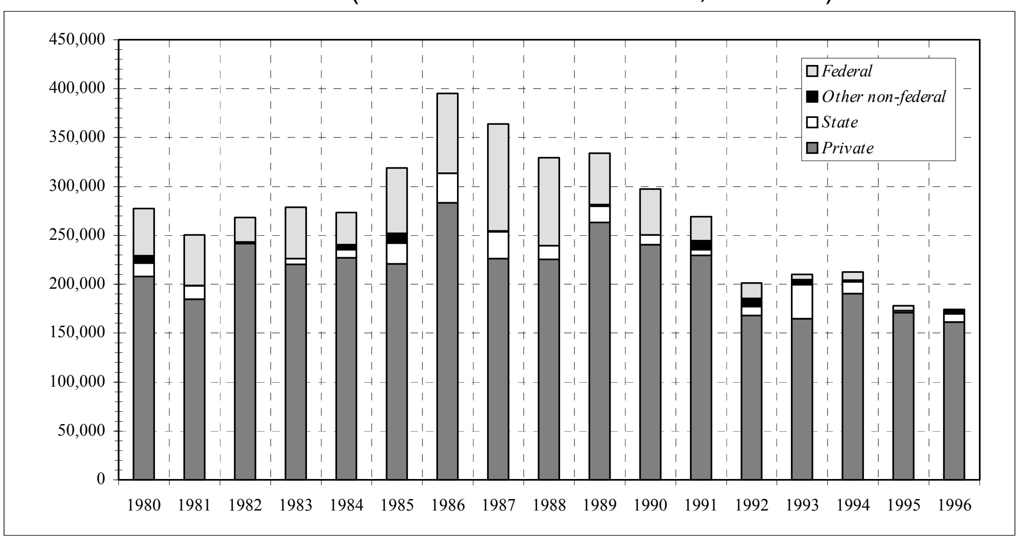
Natural Resource Industries

Natural resource industries--primarily composed of agriculture, fishing, forestry, and mining--have undergone significant change in recent years. King County's commercial fishing fleet is largely oriented toward the distant fisheries of the North Pacific. Mining and agriculture have maintained modest employment levels between 1980 and 1996. Forestry has witnessed substantial declines due to the effects of national recessions, forestry management issues, domestic reductions in timber supply, and fluctuating export markets.

Forestry

In King County, timber harvests across all ownership classes have declined; in 1996, timber harvest levels were less than half of its most recent 1986 peak of 395,148 thousand board feet (Figure 3.10-6). Publicly-owned timber, particularly from National Forests, was once a significant portion of the total annual harvest in King County. In 1996, however, privately-owned timber represented over 92 percent of the total harvest of 174,061 thousand board feet.

Figure 3.10-6. Timber Harvests in King County by Type of Ownership, 1980-1996 (in thousands of board feet, Scribner)

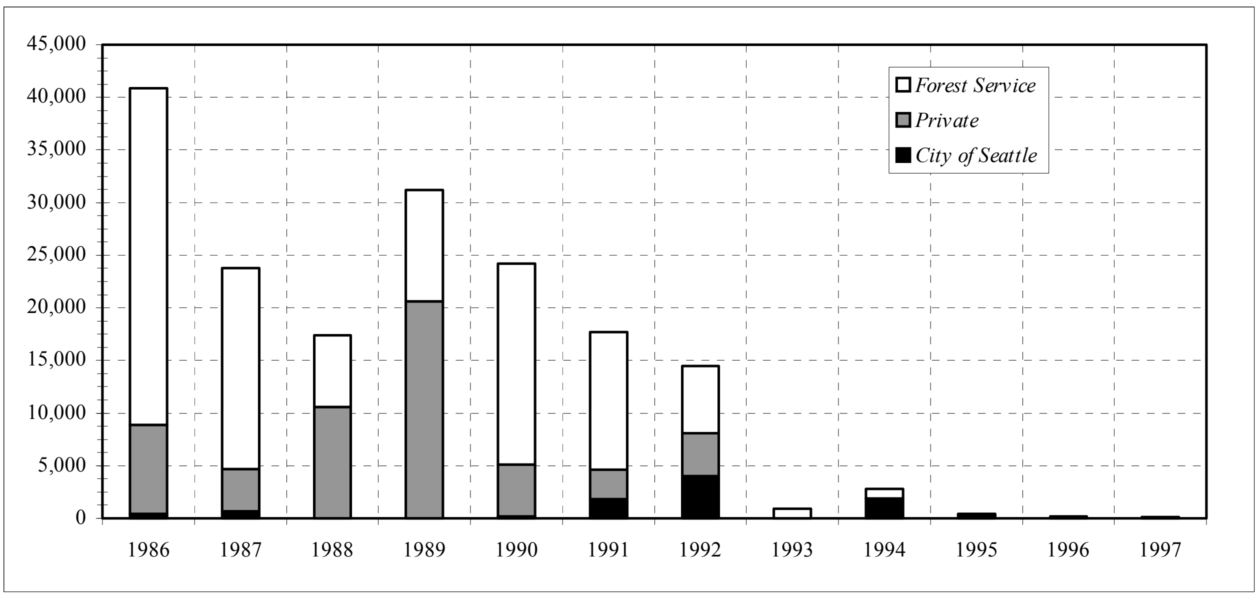


Source: Washington State Department of Natural Resources, Resource Planning & Asset Management.

The outlook for the forest products industry in King County is mixed, with the likelihood that a number of mills dependent upon public timber could close down over the next few years. Some analysts foresee a mature, restructured industry over the long-term that can remain a significant economic contributor through investments in forestry management and new technology, with more emphasis on value-added production.

In addition to hydroelectric generation and water supply, resource utilization in the Cedar River Municipal Watershed has included some timber harvest. The timber harvest program for the Cedar River Municipal Watershed is directed and regulated by City of Seattle Ordinance 114632, called the Secondary Use Ordinance (described more fully under Section 3.7 and reproduced in Technical Appendix 12). Annual timber harvested within the Cedar River Municipal Watershed has been highly variable over the last twelve years, ranging from a peak of 40,850 thousand board feet (40.85 million board feet [MMBF] in 1986 to a low of 200 thousand board feet (0.2 MMBF) in 1997 (Figure 3.10-7). The twelve-year (1986-1997) cumulative timber harvest within the Cedar River Municipal Watershed is 174,030 thousand board feet (174.03 MMBF), approximately 5.5 percent of the total cumulative timber harvest within King County during the same time period. Up to 1992, timber harvests within the Cedar River Municipal Watershed involved a mix of public and private owners. The Applicant acquired all remaining land in January 1997 within the Cedar River Municipal Watershed through a series of land exchange agreements with the U.S. Forest Service and the Mountain Tree Farm Company (jointly owned by the Weyerhaeuser Company and the Scott Paper Company).

Figure 3.10-7. Timber Harvests for All Landowners within the Cedar River Municipal Watershed, 1986-1997 (in thousands of board feet, Scribner)

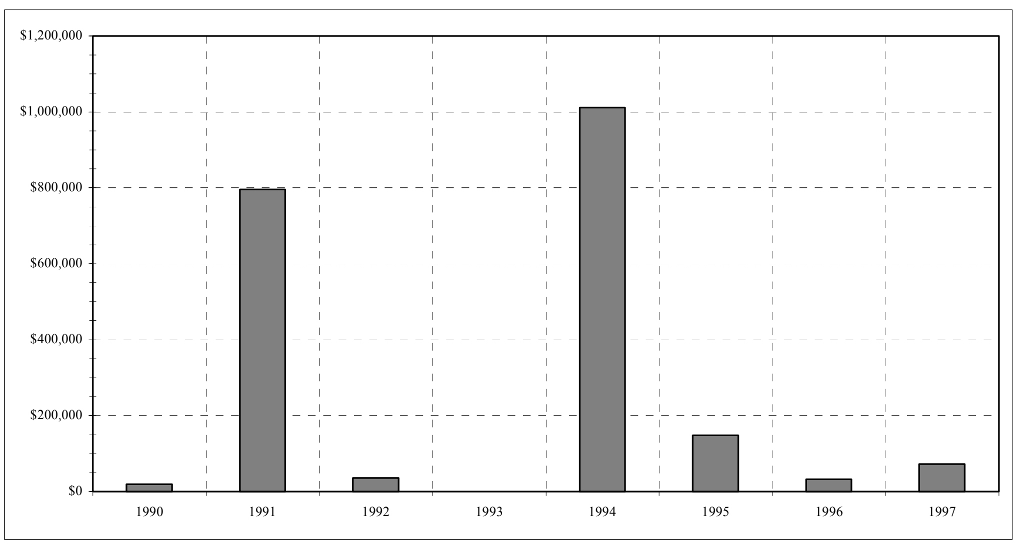


Source: City of Seattle Public Utilities.

Since 1994, all timber harvested within the Cedar River Municipal Watershed has been owned by the Applicant. The harvested areas have been inconsequential, with cumulative harvests since 1994 affecting a total of 51 acres. In 1994, the timber harvest amounted to 2,800 thousand board feet (0.28 MMBF) or 1.3 percent of the King County total timber harvest. Subsequent years have seen a continued decline in timber harvests within the Cedar River Municipal Watershed. In 1996 and 1997, total timber harvested within the Cedar River Municipal Watershed amounted to 200 thousand board feet and 120 thousand board feet (0.2 and 0.12 MMBF), respectively. Affected acreage has varied from year-to-year ranging from 918 acres in 1986 to zero acres in years 1995 and 1996. Affected acres were not recorded in 1995 and 1996 since the timber harvested were solely from salvage sales.

Gross revenues—the price paid to the Applicant by logging contractors—collected by the SPU from timber harvest activity within the Cedar River Municipal Watershed have amounted to a cumulative total of $2.12 million for the years of 1990 through 1997; on average, $264,611 each year during the period (Figure 3.10-8). By Ordinance 114632, these net timber revenues (after the costs of timber sales including reforestation) have been dedicated to the land and habitat acquisition program within the Watershed. Also, the Secondary Use Ordinance (Technical Appendix 12) established the "timber balance account" to track net timber revenues from the Cedar River Municipal Watershed as well as costs and expenditures related to land and habitat acquisition. In addition to the revenues from timber harvests in the Cedar River Municipal Watershed, the Seattle City Council elected to dedicate to the timber balance account the revenue from a 1995 salvage sale on exchange lands burned in the Tyee Creek fire.

Figure 3.10-8. Cedar River Municipal Watershed Timber Sales: City of Seattle Public Utilities Timber Harvest Receipts, 1990-1997



Note: Sales from timber harvest activity within the Cedar River Municipal Watershed subject to the Secondary Use Ordinance (114632); not included within these totals are: 1990 Entiat fire salvage sale ($844,104); and 1995 Tyee Creek fire salvage sale ($2,257,636). No timber revenues from sales were recorded in calendar year 1993.
Source: Seattle Public Utilities, 1996 and 1997 memorandum

Those costs and expenditures directly associated with the acquisition of land and habitat within the Cedar River Municipal Watershed included: (1) staff, consultant, appraisal, title and related costs of negotiating the U.S. Forest

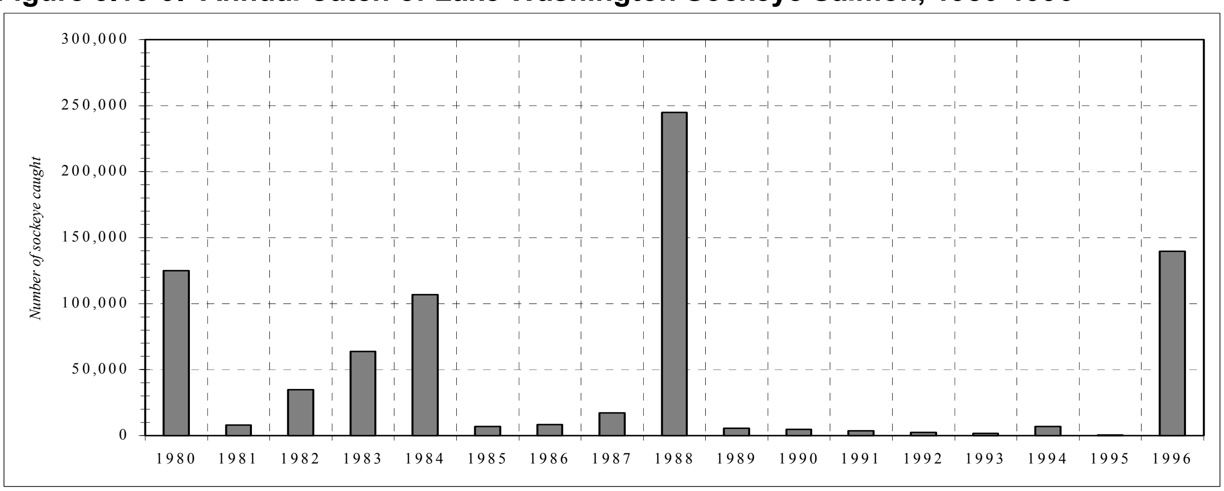
Service land exchange; (2) land acquisition from the Mountain Tree Company; and (3) costs related to the former Burlington Northern right-of-way.

Costs associated with Seattle Public Utilities' forest management program within the Cedar River Municipal Watershed include staff, supply, appraisal, consultants and contractors, and equipment costs related to: (1) preparation and implementation of timber sales, including road design, use, and maintenance; (2) reforestation and commercial thinning; (3) long-range forest management planning; (4) hydrological and biological monitoring; (4) geographic information systems support for forest management; and (5) habitat conservation planning. Current staffing requirements for administering the forest management program consists of approximately two full-time equivalents, additional temporary and seasonal employees, staff support from other work units within the utility, with outside contractual agreements employing another one to three full-time equivalent workers.

Fishing

Despite the 1996 rebound in sockeye salmon, the commercial and recreational/sport fisheries of Lake Washington are significantly reduced from its past levels; currently the area is very limited due to the simultaneous decline and depressed stock status of several important fish species. Arguably the most important fish in Lake Washington is sockeye salmon (Figure 3.10-9; Table 3.10-3).

Figure 3.10-9. Annual Catch of Lake Washington Sockeye Salmon, 1980-1996



Source: Washington State Department of Fish & Wildlife

Lake Washington sockeye salmon are harvested commercially and recreationally in both marine and freshwater regions (Table 3.10-3). Significant portions of the sockeye catch occurs in marine convention waters of British Columbia and Washington State; the majority of the catch, however, occurs in the freshwaters of Lake Washington (Table 3.10-3). The Lake Washington sockeye catch is comanaged by the State of Washington and the Muckleshoot Indian Tribe.

In the past, sockeye salmon were the object of a very intensive sport fishery with thousands of anglers fishing daily for sockeye on the lake when the season was open. The largest fisheries in recent years occurred in 1988 and again in 1996 when between 71,000 and 74,000 adult sockeye were caught by anglers. With the exception of 1996, the total sport fishery on Lake Washington amounts to less than one percent of all recreational freshwater angling within the Puget Sound region.

Given the reduced catch levels in recent years, the economic impacts of sport fishing within Lake Washington are almost negligible (Hansen, 1994). Even with a significant catch—as in 1996—the economic impacts of sport fishing are modest within the Lake Washington area. Most of the anglers are residents of the area, use private boats (compared with charter boats), and the "success" rates are low. In sum, angler-related expenditures and the resulting injection of income into the local economy from the Lake Washington recreational fishery are comparatively small.

Manufacturing

Despite slow growth since the 1980s, manufacturing remains an important component to the King County economy. In the past, the fortunes of aerospace—the County's largest manufacturing sector—were seen as a predictor of County economic performance. However, the most recent layoffs in aerospace during the early 1990s were not followed by declines in other sectors. In fact, the impact of aerospace layoffs was buffered somewhat by surges in other high technology sectors within King County. Despite the growing diversity within King County manufacturing, aerospace remains one of the primary generators of local economic growth.

Lumber and wood products, with 6,200 employees, constitutes roughly 4 percent of King County's total 1996 manufacturing workforce (Table 3.10-4). Activities surrounding lumber and wood products includes logging of timber; milling of logs into lumber, plywood, fiberboard, and hardboard; producing specialty wood products such as doors, windows, and cabinets; and manufacturing mobile homes and other wood buildings. Employment in local lumber and wood products manufacturers support a significant number of workers in the broader economy. Each lumber and wood products job has been

Table 3.10-3. Estimated Catch of Lake Washington Sockeye, 1980-1996

CATCH CATEGORY	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Marine Fishery Catches																	
Convention waters catch																	
British Columbia	3,880	1,969	2,783	2,413	2,177	1,035	1,355	1,104	3,695	928	602	2,600	1,246	1,125	2,620	207	6,711
United States	1,217	4,207	399	1,101	427	544	633	265	3,464	2,577	71	0	560	4	3,645	0	0
Discovery Bay catch																	
Treaty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Non-treaty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Admiralty Inlet catch																	
Treaty	1	0	0	9	0	0	0	0	0	0	0	0	17	0	0	0	0
Non-treaty	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Seattle Area catch																	
Treaty	1,534	21	125	112	2,092	553	130	144	25,642	159	858	186	19	40	10	1	4,844
Non-treaty	6,823	5	186	6	14	8	4	3	39,276	258	162	150	7	2	5	0	0
Marine sport	56	0	0	294	0	17	1	0	0	0	0	0	0	0	0	0	0
Freshwater Fishery Catches																	
Lake Washington catch																	
Treaty	67,487	1,805	18,780	33,902	57,684	4,556	5,752	12,480	97,469	1,763	2,845	578	468	316	390	190	53,597
Non-treaty	908	33	0	0	0	0	197	19	0	0	224	160	246	235	312	191	279
Lake Sammamish treaty	52	77	110	74	1,087	349	336	115	4,258	0	0	0	0	0	0	11	0
Lake Washington sport	43,051	0	12,462	25,851	43,400	0	12	3,117	71,230	0	0	0	0	0	0	0	74,135
Lake Sammamish sport	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Subtotals																	
Convention catch	5,097	6,176	3,182	3,514	2,604	1,579	1,988	1,369	7,159	3,505	673	2,600	1,806	1,129	6,265	207	6,711
Marine treaty	1,535	21	125	121	2,092	553	130	144	25,642	159	858	186	36	40	10	1	4,844
Marine non-treaty	6,879	5	186	300	14	25	5	3	39,276	258	162	150	7	2	5	0	0
Freshwater treaty	67,539	1,882	18,890	33,976	58,771	4,905	6,088	12,595	101,727	1,763	2,845	578	468	316	390	201	53,597
Freshwater non-treaty	43,959	33	12,462	25,851	43,400	0	209	3,136	71,230	0	224	160	246	235	312	191	74,414
Totals																	
Total catch	125,009	8,117	34,845	63,762	106,881	7,062	8,420	17,247	245,034	5,685	4,762	3,674	2,563	1,722	6,982	600	139,566
Cedar R. Enhancement	10,662	4,203	0	0	0	0	0	0	0	0	0	787	1,078	3,029	2,486	3,546	9,590
Escapement	361,000	107,000	289,000	226,815	372,000	254,000	249,000	207,000	376,000	166,247	93,000	87,000	155,000	93,000	155,000	26,000	307,000
Actual Run Size	496,671	119,320	323,845	290,577	478,881	261,062	257,420	224,247	621,034	171,932	97,762	91,461	158,641	97,751	164,468	30,146	456,156

Source: Washington State Department of Fish & Wildlife estimated to support an additional 2.5-3.0 jobs within the local economy (Chase et al., 1987).

Services

During the 1980s and continuing into the 1990s, services employment in King County, as in many areas of the nation, grew the fastest of any economic sector. Service establishments include a diverse array of companies that can be

Table 3.10-4. Manufacturing Employment in King County, 1996

Manufacturing sector	*1996 Employment*
Aerospace	52,900
Food processing	15,400
Printing & publishing	11,900
Industrial machinery	8,000
Lumber & wood products	6,200
Electronic & other electric equipment	6,000
Instruments & related products	5,900
Fabricated metals products	5,500
Other transportation equipment	4,200
Textiles, apparel and leather	3,700
Stone, clay & glass products	3,600
Ship & boat building & repair	2,600
Paper & allied products	2,500
Other manufacturing	13,000
TOTAL MANUFACTURING	*141,400*

Sources: Washington State Employment Security Department, Labor Market & Economic Analysis Branch. *Labor Force and Employment in Washington State*, 1997.

classified according to the types of services provided and types of markets served: producer services (e.g., engineering, architectural, legal, finance, software, and other business and professional services); and nonproducer services (e.g., health and social services, consumer services).

Producer services are composed of a broad array of service industries whose most important markets are other manufacturing and services companies, public agencies and private organizations, rather than individual consumers. Between 1980 and 1996, employment within King County's producer services grew very rapidly, tripling in size to 131,100 workers. Non-producer services are generally divided into two categories: health services; and consumer services, such as social and personal services, auto repair, and hotel lodging. During the 1980s and early 1990s, health services were a significant job creator, but employment growth has recently slowed due to cost controls and slowdown in population growth.

Included within consumer services is social and educational services and recreation and tourism. King County and Seattle have received increasing attention as a tourist destination. King County's strategic location as an international gateway to the Pacific Rim plays an important role in bringing visitors to the Pacific Northwest and Washington State. In 1995, travel expenditures of $4.1 billion directly supported over 46,500 jobs (or 4.7 percent of total employment) in King County. These jobs are widely dispersed among retail, lodging, transportation, recreation, entertainment, and other types of services.

Construction

Another prime generator of King County's economic growth in recent years has been the construction industry, providing buildings for other growing sectors and housing for employees as well as government-financed infrastructure projects. Evidence of the local economic rebound appears in construction statistics for new residential units authorized for the Seattle metropolitan area. With a 15 percent increase in new construction in 1996, it appears that the building recession of the early 1990s is over. The recovery is still rather modest in single family construction; up less than one percent from 1995. Significant growth has occurred in multifamily units. After several stagnant years, multifamily increases within the Seattle metropolitan region pushed up total construction figures as builders strove to meet growing demand.

Utilities

Water

SPU currently supplies water to 1.3 million people throughout King County. They're served either directly to the end-user by the Seattle Public Utilities through its retail operations or through 26 cities, water districts and associations—frequently referred to as "purveyors"—that purchase some or all of their water from Seattle on a wholesale basis under water service contracts. Serving these customers requires an annual average of 150 MGD. Water from the Cedar River supplies approximately 70 percent of the SPU's total needs.

In terms of revenue, residential retail customers contribute more than 37 percent of SPU's estimated total 1997 operating revenues of $70.46 million (Table 3.10-5). Commercial retail customers contribute another 32.5 percent of total operating revenues. Purveyors, which buy about 45 percent of Seattle's available water at wholesale prices, contribute about 28 percent of SPU's total revenue.

Table 3.10-5. Seattle Public Utilities Water Division: Actual 1997 and Forecasted 1998 Operating Revenues

	Residential	Commercial	Fire Service	Direct Service	Purveyor	TOTAL
1997 ($000)	$26,122	$22,876	$1,437	$50,436	$20,028	$70,464
Percent of Total	37.1%	32.5%	2.0%	71.6%	28.4%	100.0%
1998 ($000)	$29,437	$25,054	$1,625	56,116	$27,435	$83,551
Percent of Total	35.2%	30.0%	1.9%	67.2%	32.8%	100.0%

Source: Seattle Public Utilities, Water Division

Both retail and wholesale rates—established by ordinance by the City of Seattle—are based on overall revenue requirements sufficient to meet anticipated operations and maintenance (O&M) expenses, debt service obligations, and the Water Division's financial policies. Once revenue requirements have been determined, the next step is to allocate these revenue requirements among major customer classes (purveyors and direct service) and direct service customer classes (residential and commercial). Due to competing interests and equity concerns (e.g., purveyors do not wish to pay more than their fair share of costs and Seattle ratepayers do not want to subsidize their suburban neighbors), cost allocations are a critical part of the rate process.

The cost allocation process includes:

- Classification—organizing facilities and services into logical categories which simplify the process of identifying costs and dividing these costs between wholesale and direct service customers
- Allocation—dividing the value or cost of a category between purveyors and direct service customers based on primarily water use and made on a separate facility-by-facility (e.g., Cedar and Tolt supply sources) basis
- Amortization—taking the costs and values allocated to purveyors and direct service customers and transforms them into a monetary amount that will be recovered from rates in a particular year (operating expenses are always recovered in the year they occur; capital expenditures for new and expansion of facilities are recovered over time) and
- Variance adjustment—a corrective mechanism to "true-up" forecasting (or computational) errors that occur for either revenues or expenditures for purveyors.

Income from other sources other than rates (such as interest income, rentals, timber and land sales) represents approximately one-tenth of the Water Division's total revenues. Nonrevenue water, a term used to describe water which does not generate revenue, is estimated on average at 15 MGD or about 10 percent of total daily use.

The operating revenues of SPU are fully committed to meeting operations and maintenance expenses as well as meet debt service obligations of approximately $22 million per year. Proposed capital improvements include major treatment facilities on both the Cedar and Tolt Rivers; new transmission pipelines; expenses of the Habitat Conservation Plan; and ongoing improvements to upgrade pump stations, replace water mains, and aged facilities.

3.10.5 Summary

The affected socioeconomic environment of the proposed HCP includes the City of Seattle and the broader King County region.

The population of Seattle has remained relatively constant since 1980. In contrast, King County—Washington State's most populated county—has experienced an average annual growth of 1.8 percent between 1980 and 1996. Economic activity has also increased within the state's largest economy; since 1980, employment growth in King County has averaged 3.1 percent on an annual basis. This growth in population and economic activity has not translated into increased water demand. Indeed, total water consumption within the Seattle Water Division's service area has declined between 1982 and 1997.

Over the years, growth and change within the regional economy has resulted in natural resource industries contributing a decreasingly smaller share to King County's economy. Less than one percent of all workers in King County are employed in natural resource industries. Timber harvests within the County are now less than half of its 1988 peak. Within the Cedar River Municipal Watershed, timber harvests have fallen to less than 200 thousand board feet annually.

Likewise, commercial and recreational/sport fisheries within Puget Sound, and specifically, Lake Washington, are significantly reduced from its past levels. With the exception of 1996, the sport fishery on Lake Washington amounts to less than one percent of all recreational freshwater angling within the Puget Sound region. Consequently, the economic activity from such activity is almost negligible.

Water rates of the Seattle Public Utilities Water Division are established by City ordinance and are currently sufficient to meet anticipated operations and maintenance expenses and current debt service obligations. The rate policy ordinance outlines a required scope of issues, basic methodological approaches for determining revenue requirements and cost allocations between wholesale and retail customers, and rate design.

Section 4.10 will discuss the effects of the various alternatives in relationship to the revenues generated by timber harvest; effects of the lack of timber revenue on water rates; employment created by timber harvest; and the economic effects of an enhanced recreational and commercial sockeye fishery.